O P E R A T I N G M A N U A L

930A COMMUNICATIONS TEST SET

SAGE
INSTRUMENTS

OPERATING MANUAL

930A COMMUNICATIONS TEST SET

SAGE INSTRUMENTS

WARRANTY

The SAGE Instruments 930A is warranted to be free from defects in materials or workmanship for a period of one year from the date of shipment. During the warranty period, SAGE will, at its option, either repair or replace products which prove to be defective at SAGE's expense.

Any repairs for damages from accident, misuse, shipment in other than approved packaging, or improper repair by other than SAGE Instruments' technicians or their authorized service facilities are not covered by this warranty. All out of warranty repairs will be done at the customer's expense based upon time and materials.

SAGE Instruments warrants that firmware provided for the 930A will execute its programming instructions when properly installed. SAGE does not warrant the operation of the instrument to be continuous or error free. If improper operation of the Model 930A is suspected, contact SAGE Instruments at (408) 761-1000. Upon verification of problem with Customer Service, a Returned Material Authorization number will be issued for the instrument.

EXCLUSIVE REMEDIES

The remedies provided herein are the **original buyer's** sole and exclusive remedies. SAGE Instruments is not liable for consequential damages or damages to any party other than the **original buyer**. SAGE Instruments specifically disclaims any implied warranty of merchantability or fitness for a particular purpose. No other warranty is expressed or implied.

SHIPPING INSTRUCTIONS

After obtaining return material authorization number, ship the Model 930A, in its original container, postage prepaid, to:

SAGE INSTRUMENTS
240 Airport Blvd.
Freedom, CA 95019-2614
(408) 761-1000
ATTN: REPAIR

Include a detailed description of the problem and the conditions and circumstances under which the symptoms occurred. **IF THE ORIGINAL PACKAGING (OR APPROVED EQUIVALENT) IS NOT USED, THE WARRANTY WILL BE VOID.**

SAGE INSTRUMENTS
MODEL 930A
COMMUNICATIONS TEST SET

OPERATIONS MANUAL

REVISION 1.9 9/1/88

SAGE INSTRUMENTS
240 AIRPORT BLVD.
FREEDOM, CA 95019-2614
(408)761-1000

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SECTION I
GENERAL INFORMATION

1-1 INTRODUCTION

This operating manual contains general information regarding the installation and operation of the SAGE Model 930A Communications Test Set. Figure 1-1 shows the instrument and optional accessories available.

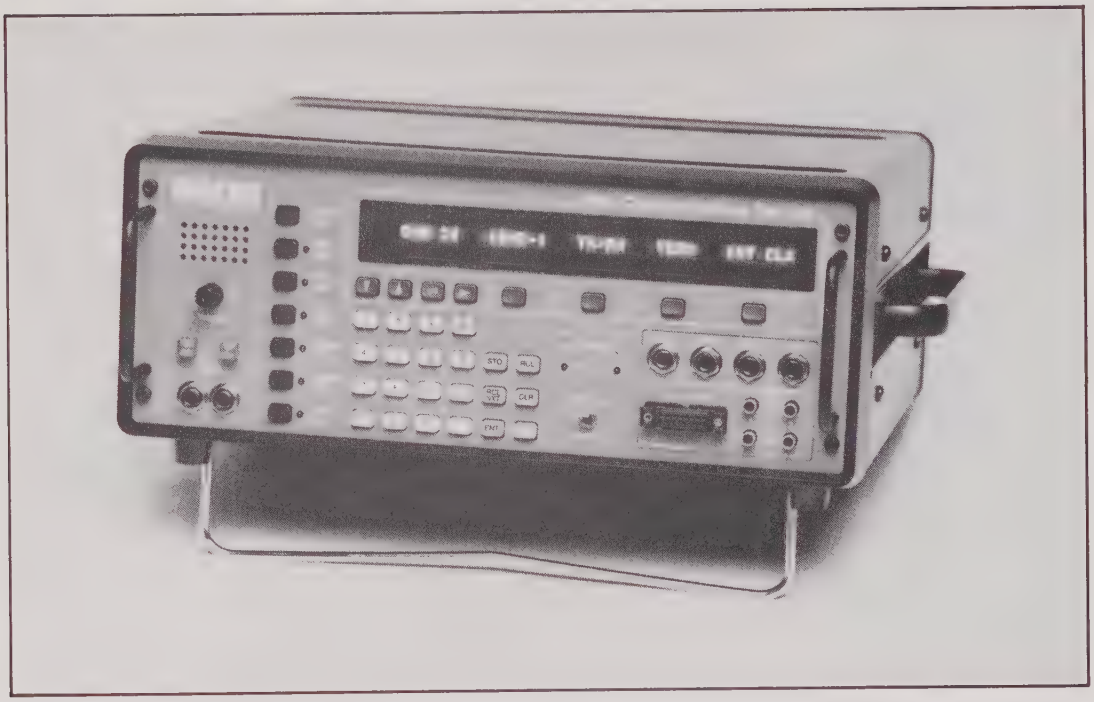
1-2 SPECIFICATIONS

The instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested. Options for the instrument have separate specifications which are provided on supplementary specification sheets.

1-3 DESCRIPTION

The Model 930A Communications Test Set combines the functions of a Transmission Impairment Set, a Return Loss Measurement Set, Dial Pulse, Touch Tone (DTMF) and Multi-Frequency (MF) Sender, and Talk Battery supply into one lightweight package. Hardware and software options allow the user to greatly increase the capabilities of the 930A. These options include:

DP, DTMF, MF Receiver/Analyzer with Trunk Simulation
SF Supervision
P/AR Receiver/Transmitter
3-Level Impulse Noise
RS-232C Remote Control/Printer Interface
DS-1 PCM Transmit/Receive (Single or Dual Direction)
Type 105 ROTL/Interrogator/Responder (52A Format)
Ring Generator/REN-3 Load
LTTP/STTP Interface (#1/1A ESS Switch)
FXO/FXS Supervision
DACS Interface
Phase/Amplitude Jitter and Hits Measurement
Non-Linear Distortion Measurement
Envelope Delay Distortion Measurement



MODEL 930A AND ACCESSORIES
FIGURE 1-1

The instrument, while general purpose in nature, is particularly useful for DEMARC and Central Office testing as well as PBX and digital switch installation testing. It is capable of performing all transmission and signalling tests required at these locations, including those for Feature Groups A-D (Equal Access). The Model 930A can completely simulate either a PBX or a Central Office switch. The procedures for performing these tests are described in Sections III and IV of this manual.

1-4 ACCESSORIES AVAILABLE

The following accessories are available:

1. 80 Column Dot Matrix Printer and Cable,
   SAGE P/N 9400-0001-01
2. Test Cord, bantam male to bantam male, 96 inches
   SAGE P/N 9400-0002-01
3. Adapter , 310 male to bantam female,
   SAGE P/N 9400-0003-01
4. Test Cord, 310 male to 310 male, 60 inches
   SAGE P/N 9400-0004-01
5. Test Cord, 310 male to alligator clip, 60 inches
   SAGE P/N 9400-0005-01
6. Standard 19-inch rack mounting kit,
   SAGE P/N 9400-1001-01
7. Standard 23-inch rack mounting kit,
   SAGE P/N 9400-1002-01
8. Padded Vinyl Carrying Case,
   SAGE P/N 9400-1003-01
9. Industrial Grade Shipping Case,
   SAGE P/N 9400-1004-01

1-5 WARRANTY

Warranty information is listed on the inside of the front cover.

TABLE 1-1 *Specifications*

LEVEL/FREQUENCY

TRANSMITTER

Frequency Range:	20 Hz to 5000 Hz
Resolution:	1 Hz
Accuracy:	+/- 1.0 Hz
Output Steps:	1 Hz, 10 Hz, 100 Hz, or 1000 Hz steps
Frequency Sweep:	Single or Continuous with selectable bounds, level and step size.
Level Range:	- 60 dBm to + 12 dBm
Resolution:	0.1 dB
Accuracy:	+/- 0.1 dB @ 1004 Hz (0 to -19 dBm),
Flatness:	+/- 0.2 dB (200 Hz to 5 KHz referenced to level at 1 KHz)
Distortion:	- 70 dB @ 1004 Hz, 0 dBm

RECEIVER

Frequency Range:	20 Hz to 5000 Hz
Resolution:	1 Hz
Accuracy:	+/- 1.0 Hz
Level Range:	- 50 dBm to + 12 dBm
Resolution:	0.1 dB
Accuracy:	+/- 0.1 dB @ 1004 Hz (0 to -19 dBm), +/- 0.2 dB @ 200 Hz to 5 Khz

NOISE MEASUREMENTS

Input:	Balanced or Noise to Ground
Weighting Filters:	C-MSG, C-NOTCH, 3 KHz Flat
Notch Filter:	1010 Hz (995 Hz to 1025 Hz Notch); > 60 dB Notch depth
Range:	10 dBrn to 100 dBrn (Balanced) 50 dBrn to 130 dBrn (Noise to Ground)
Resolution:	1.0 dB
Accuracy:	+/- 0.5 dB

TABLE 1-1 *Specifications(con't)*

SIGNAL TO NOISE MEASUREMENT

Level Range:	-50 dBm to +10 dBm
Noise Range:	10 dBrn to 90 dBrn
S/N Range:	10 dB to 70 dB
Accuracy:	+/- 0.5 dB
Resolution:	1.0 dB

RETURN LOSS MEASUREMENT

Modes:	ERL, SRL-Low, SRL-High or Sinewave (OSCillator mode)
Transmitted Signal:	Meets the specifications of Bell Publication 41009 (Tables D, E and F, page 13) and IEEE Standard 743-1984

2-WIRE RETURN LOSS

Transmitter Level:	-10 dBm0
Receiver Range:	0 dB to 40 dB
Resolution:	1.0 dB
Accuracy:	+/- 0.5 dB
Internal Hybrid Impedance:	600 or 900 ohms +/- 0.1% in series with 2.16 uF +/- 1%

4-WIRE RETURN LOSS

Impedance:	150, 600, 900, or 1200 ohms
Transhybrid Loss Compensation:	- 30 dB to + 30 dB
Transmitter Level:	- 10 dBm0 In OSCillator mode the level is 0 dBm relative to the TLP.
Receiver Range:	-10 dB to 50 dB
Resolution:	1.0 dB
Accuracy:	+/- 0.5 dB

TABLE 1-1 *Specifications (con't)*

SUPERVISORY SIGNALING

WINK TIMING

Resolution:	5 msecs.
Accuracy:	+/- 5 msecs.
Wink Fail Event:	Fails for wink period >600 msecs.
Off-Hook Fail Event:	Fails for Off-Hook period <600 msecs.

E/M SUPERVISION

Types:	I, II, III, IV, V
Battery:	- 48 VDC current limited to 200 mA

Threshold Voltages:

	E Lead	M Lead
On Hook	< - 16 V.	> - 16 V.
Off Hook	> - 16 V.	< - 16 V.

LOOP SUPERVISION

Types:	2 and 4 Wire Loop Start, Ground Start, Loop Reverse Battery, and SX supervision.
Battery:	- 48 VDC series limited to 120 mA

MF AND DTMF SENDER

Frequency Accuracy:	+/- 0.1% of Bell Standard Frequencies
Adjustment Range:	Tone Frequencies adjustable in 0.1% steps to +/- 10% of standard Bell frequencies for Margin Testing.
Level:	Automatically adjusted to -7 dBm0.
Level Adjustment Range:	Tone level adjustable in 0.1 dB steps from - 60.0 dBm to + 6.0 dBm.

TABLE 1-1 *Specifications (con't)*

Resolution:	0.1 dB
Accuracy:	+/- 0.2 dB
Timing:	MF: 70 ms Tone On and Tone Off (KP is 100 mS Tone On) DTMF: 50 ms Tone On and Tone Off
Timing Adjustment Range:	Tone On and Tone Off times adjustable in 1 ms steps from 13 msecs. to 267 msecs.
Resolution:	1 msecs.
Accuracy:	+/- 1.0 msecs.

DIAL PULSE SENDER

PPS

Range:	2 to 50 PPS
Resolution:	0.1 PPS
Accuracy:	+/- 1.0% at 10 PPS

% BREAK

Range:	5 to 95%
Resolution:	0.1%
Accuracy:	+/- 1.0% for 25% to 75% BRK @ 10 PPS

INTERDIGIT TIMING

Range:	40 to 990 msecs.
Resolution:	10 msecs.
Accuracy:	+/- 5 msecs.

TABLE 1-1 *Specifications (con't)*

GENERAL

Impedances:	150, 600, 900, 1200 ohms and > 50 Kohms Bridging
Maximum DC Blocking:	160 VDC
Audio Bandwidth:	+/- 3.0 dB 300 Hz to 3.0 KHz
Audio Volume:	Adjustable by front panel control
Longitudinal Balance:	90 dB at 60 Hz
Receiver Return Loss:	> 30 dB 200 Hz to 5 KHz (600, 900, 1200 ohms) > 30 dB 800 Hz to 5 KHz (150 ohms)
Display:	40 character vacuum fluorescent plus 4 LED's for ON/OFF Hook status
AC Power Supply:	115 VAC +/- 10%, 60 Hz
Operating Temperature:	0 C to 50 C
Storage Temperature:	- 40 C to 70 C
Dimensions:	5.79" H. x 14.33" W. x 14.25" D.
Weight:	16 to 18 lbs. depending upon options.

OPTIONS

MF/DTMF/DP RECEIVER AND ANALYZER (OPTION 930A-01)

MF AND DTMF

Input Level Range:	-30 dBm0 to 0 dBm0
Accuracy:	+/- 0.2 dB
Resolution:	0.1 dB
Input Frequency Range:	+/- 10% of AT&T standard frequencies for MF and DTMF tones.
Accuracy:	+/- 0.1%
Resolution:	1 Hz
Input Tone ON/OFF Range:	35 msecs. to 250 msecs. Tone ON 35 msecs. to 250 msecs. Tone OFF
Accuracy:	+/- 5 msecs.
Resolution:	1 msecs.

TABLE 1-1 *Specifications (con't)*

DIAL PULSE (DP) RECEIVER AND ANALYZER (OPTION 930A-01)

PPS Range:	5 PPS to 30 PPS
Accuracy:	+/- 2% @ 10 PPS
Resolution:	0.1 PPS
% Break:	10% to 90%
Accuracy:	+/- 2% (25% to 75% break at 10 PPS)
Resolution:	0.1%
Interdigit Timing Range:	50 msecs. to 990 msecs.
Accuracy:	+/- 5 msecs.
Resolution:	1 msec.

SF SUPERVISION (OPTION 930A-02)

SF Oscillator:	2604 Hz, +/- 1.0 Hz
Send Level:	-36 dBm0 On Hook, -13 dBm0 pulse
Receiver Sensitivity	-42 dBm0

PEAK TO AVERAGE RATIO (P/AR) (OPTION 930A-06)

Transmit Level Range:	0 dBm to -40 dBm
Resolution:	0.1 dB
Receive Level Range:	-40 dBm to +12 dBm
Resolution:	0.1 dB
P/AR Measurement Range:	0 to 120 P/AR units
Resolution:	1 P/AR unit
Accuracy:	+/- 1 P/AR unit

3-LEVEL IMPULSE NOISE (OPTION 930A-07)

Weighting Filter:	C-Notch or C-Message
Threshold Range:	30 dBrnC to 106 dBrnC
Accuracy:	+/- 1.0 dB
Threshold Spread:	2, 4, 6, or 8 dB steps
Timer:	1 min. to 99 mins. or continuous
Counter Capacity:	0 to 9999 for LO, MD and HI.
Measurements Range:	7 to 99 measurements per second.

TABLE 1-1 *Specifications (con't)*

DS-1 PCM DROP/INSERT OPTIONS (OPTIONS 930A-08 AND -09)

Format:	DS-1 AMI Line Code
DS-1Input Frequency:	1.544 Mbps +/- 500 bps
Channel Numbering Sequence:	D1D, D2, D3/D4
Signaling Mode:	NORM (Robbed Bit) or CCIS
Input Mode:	Terminated: 100 ohms nominal Bridging: >1000 ohms
Input Level:	200 mV to 6.0 V base to peak
DS-1 Output:	1.544 Mbps +/- 25 bps
Output Pulse Level:	3.0 V nominal base to peak into 100 ohms resistive load
Channel Selection:	Any one of 24 selectable from keypad
PCM Supervision Displays:	40 character vacuum fluorescent display shows A or B bit signaling states for all 24 channels (Menu option #20) simultaneously. Shows state of A and B bits on selected channel bidirectionally (Menu Option #21). 4 LED's show status of ON/OFF Hook supervision of selected time slot.
Operating Modes:	TX/RX, THRU, Dual Direction Drop/ Insert (Opt. 930A-09) with front panel selection of transmission direction.
Pattern Simulation:	Idle Code (All Ones) Received PCM (THRU Mode)

PCM CHANNEL ENCODER

Analog Tone Generation:	20 Hz to 3904 Hz selectable in 1.0 Hz steps from keypad
Tone Level:	+3.0 dBm to -50.0 dBm in 0.1 dB steps selectable from keypad
Frequency Response:	+/- 0.1 dB (20 Hz to 3904 Hz)
Basic Accuracy:	

Accuracy	Level
+/- 0.1 dB	+3.0 dBm0 to -30 dBm0
+/- 0.2 dB	-30 dBm0 to -40 dBm0
+/- 0.5 dB	-40 dBm0 to -50 dBm0

TABLE 1-1 *Specifications (con't)*

Supervision: A and B bits (0 and 1 states user defineable in Menu Option #21)

Signaling: MF, DTMF and DP

PCM CHANNEL DECODER

Recovered Analog Tones: 50 Hz to 3904 Hz, +/- 1 Hz

Recovered Level: +3.0 dBm to -40.0 dBm

Basic Accuracy: +/-0.1 dB with Digital Milliwatt

Accuracy	Input Level
+/-0.1 dB	+3.0 dBm0 to -30 dBm0
+/-0.2 dB	-30 dBm0 to -40 dBm0
+/-0.5 dB	-40 dBm0 to -50 dBm0

Frequency Response: +/-0.1 dB @ 204 Hz to 3904 Hz with 0 dBm applied.

Supervision: On-Hook and Off-Hook supervision are user defineable as any combination of A and B bits (i.e., 0, 1, or "don't care"). FXO/FXS supervision available with Option 930A-25.

Signal to Total Distortion:

Input	7 5/6 Sgnlng	CCIS
0 to -30 dBm0	38 dB	40 dB
-30 to -40 dBm0	36 dB	36 dB
-40 to -50 dBm0	32 dB	32 dB

Gain Tracking Error:

Input	Max. Deviation
+3.0 to -30 dBm0	+/-0.1 dB
-30 to -40 dBm0	+/-0.2 dB
-40 to -50 dBm0	+/-0.5 dB

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SECTION II
INSTALLATION

2-1 INTRODUCTION

This section provides information regarding initial inspection and damage claims, preparation for operation, power requirements, storage and shipment. Also provided is a physical description of the Model 930A.

2-2 INITIAL INSPECTION

When the instrument arrives inspect the shipping container for visible signs of stress or damage. If the shipping container or packaging material is damaged notify the carrier as well as SAGE immediately. Retain the materials until the contents have been checked mechanically and electrically. The contents of the shipment should be one Model 930A, one copy of the Operating Manual, and one AC power cord. Accessories may or may not be shipped in the same container as the Model 930A depending upon their size. Check the shipping invoice carefully against the contents received.

2-3 PREPARATION FOR USE

CAUTION

This instrument is designed to operate on 115 VAC, 60 Hz power. Connection to a power source other than this will cause damage to the Model 930A. Consult the factory for optional power sources.

Connect the Model 930A to any standard three conductor outlet of 115 VAC, 60 Hz using the power cord supplied with the unit. The three wire power cord supplied with the unit grounds the instrument.

WARNING

Do not interrupt the protective (ground) conductor (inside or outside the instrument) or disconnect the protective earth terminal as this can make the instrument an electrical shock hazard.

SAGE INSTRUMENTS MODEL 930A
FIGURE 2-1

2-4 OPERATING ENVIRONMENT

This instrument may be operated in temperatures from 0 degrees C to 50 degrees C (+ 32 degrees F to + 122 degrees F). The instrument will operate in environments with humidity from 10 to 90% relative humidity, non-condensing, at +40 degrees C (104 degrees F).

2-5 STORAGE AND SHIPMENT

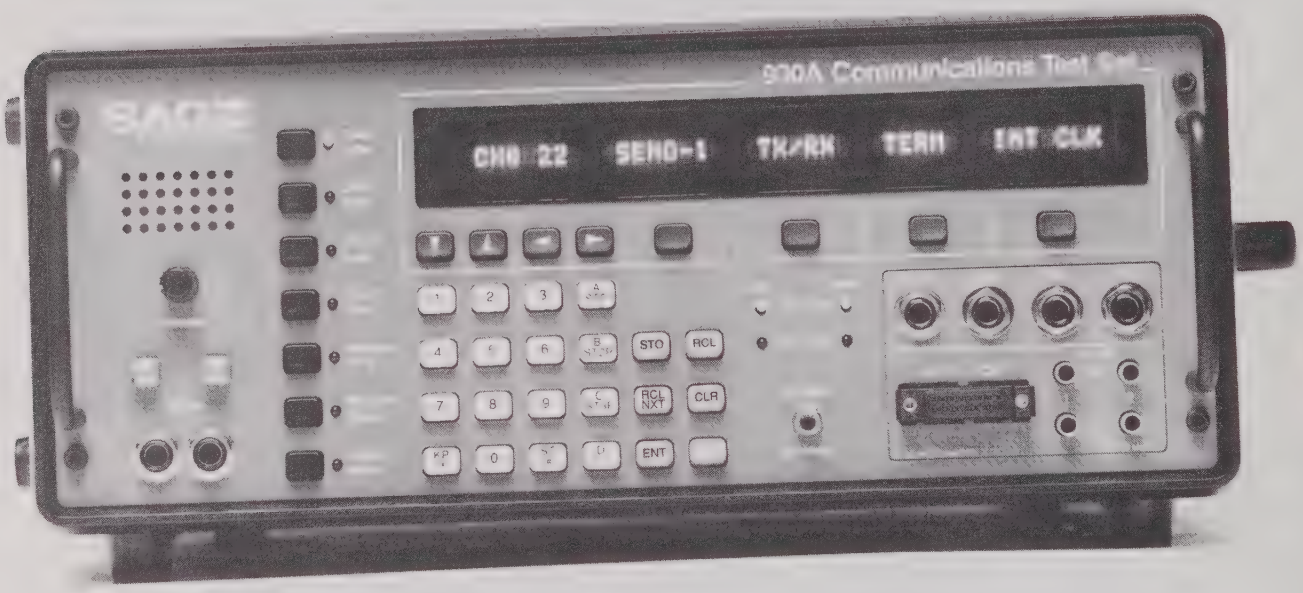
The instrument may be stored and shipped within the following environmental limits:

* Temperature -40 to +70 degrees C
* Humidity Up to 90% Relative @ +65 degrees C

Shipment of the instrument for return to SAGE is facilitated by retaining the original shipping container and packing materials. In the event that the original container is no longer available the following general instructions should be used for repackaging the instrument with commercially available materials.

1. Include return address, serial number, and name of technical contact when returning instrument for service.
2. Use a double-walled carton made of at least 350 pound test material and of a size which permits space for shock-absorbing material.
3. Use a 3-4 inch layer of shock absorbing material on all sides top and bottom of the instrument. Protect the front panel with cardboard.
4. Seal the container securely.
5. Mark the container FRAGILE to ensure careful handling.
6. Refer to the instrument model number and serial number in any correspondence.

The instrument warranty will be voided if an instrument is returned and found to be improperly packaged.



MODEL 930A FRONT PANEL
FIGURE 2-2

2-6 PHYSICAL DESCRIPTION

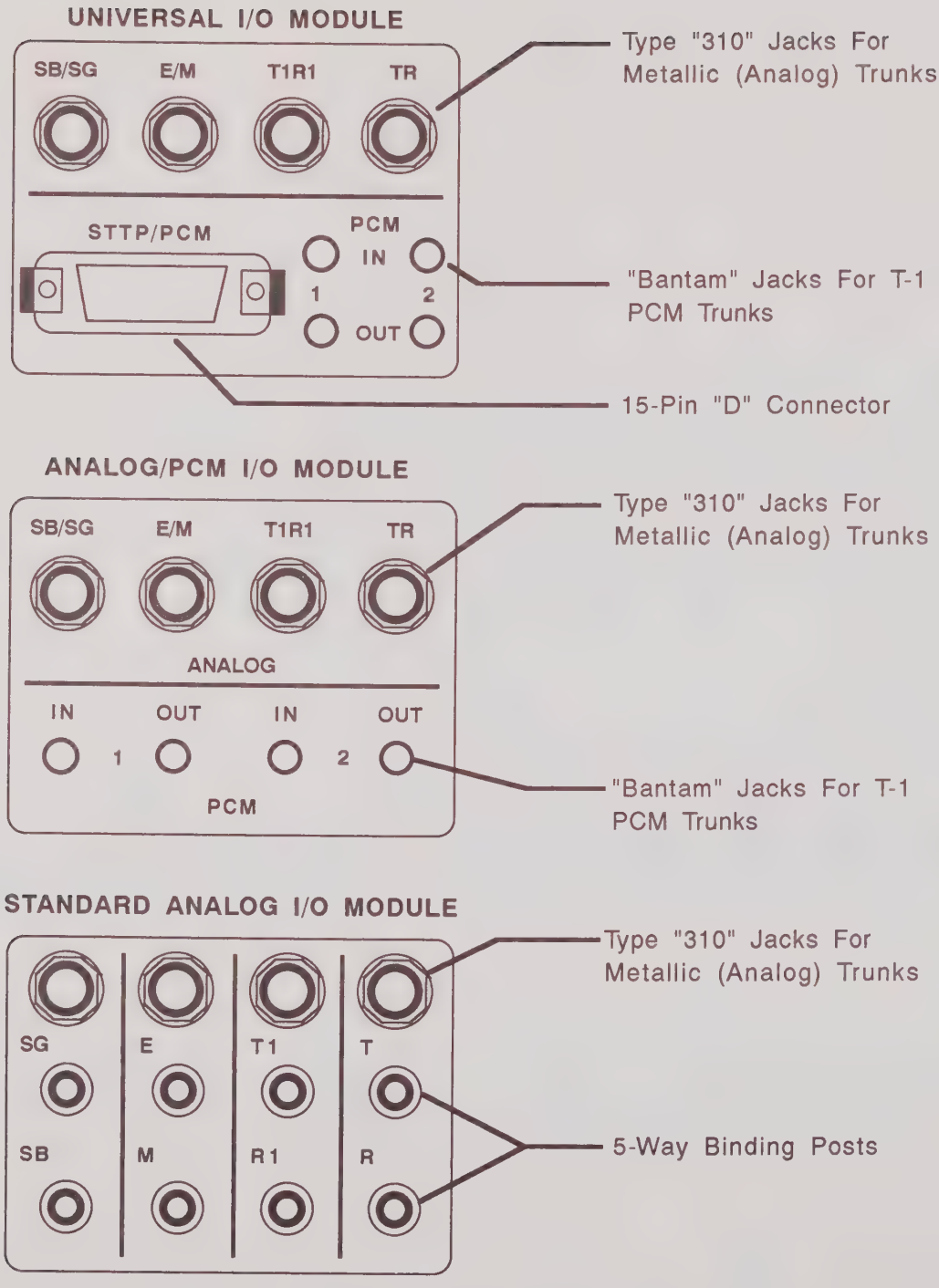
The SAGE Instruments Model 930A shown in Figure 2-1 measures 5.79" H. x 14.33" W. x 14.25" D. A convenient carrying handle extends 1.25" from the right side of the instrument case. Two smaller carrying handles extend 1.25" from the front panel of the Model 930A. Four rubber feet extend 0.5" from the left side of the case. Four large plastic feet extend 1" from the rear panel of the unit permitting the operator to set the unit on end when performing tests at the DSX jackfield. The unit normally sits on the four plastic feet which extend 0.5" from the bottom of the case. For ease of viewing by the operator the Model 930A is equipped with a pivot brace inside the front feet which raises the front of the unit three inches when extended.

The front panel shown in Figure 2-2 measures 5.25" H. x 13.5" W. It contains 37 keys, 11 LED's, a speaker grill, a volume control knob, two carrying handles, a hook switch, a 2.25" x 3.25" configurator panel which contains the input/output connectors, a 40 character alphanumeric Fluorescent Indicator Panel, and a connector for a headset and butt-in.

The configurator panel is located in the lower right side of the front panel as shown in Figure 2-2. Depending upon which configurator has been ordered, it will contain some combination of 310 jacks, bantam jacks, 5-way binding posts, or a 15 pin subminiature D type connector. Various configurators are shown in Figure 2-3.

The "A" configurator panel is used in those units which are intended for use in an entirely analog environment and which have no PCM module options. The 310 jacks are for the analog input/output and are labeled SB/SG (Signal Battery/Signal Ground), E/M (The E and M leads), T/R (Tip and Ring), and T1/R1 (Tip-1 and Ring-1). The E/M and SG/SB leads are used for E&M signaling. TR and T1R1 are used by all 4-wire analog trunks. All 2-wire signaling and transmission is done over TR. The binding posts are below their corresponding 310 jacks and are labeled SG, SB, E, M, T, R, T1, and R1.

The "A/P" configurator is intended for use in those units which have both analog and digital (DS-1 PCM) capability. That is, option 930A-08 or -09 has been installed. The bantam or tiny telephone jacks provide digital access for the PCM trunks. They are labeled PCM1 IN, PCM1 OUT, PCM2 IN, and PCM2 OUT.



CONFIGURATOR PANELS
FIGURE 2-3

The "UNIV" configurator is intended for use with analog/digital trunks and also has a 15 pin subminiature D type connector for use with the SAGE Model 114A Supplementary Trunk Test Panel Adapter. This would mean that option 930A-14 has been installed.

The rear panel shown in Figure 2-4 measures 5" x 13.5" and contains the following:

ON/OFF Switch
Recessed connector for three-prong power cord
Fuse Holder
Fan Grill
Grounding Lug
25 pin RS-232C "D" type connector (optional)
Four plastic feet with soft rubber tips

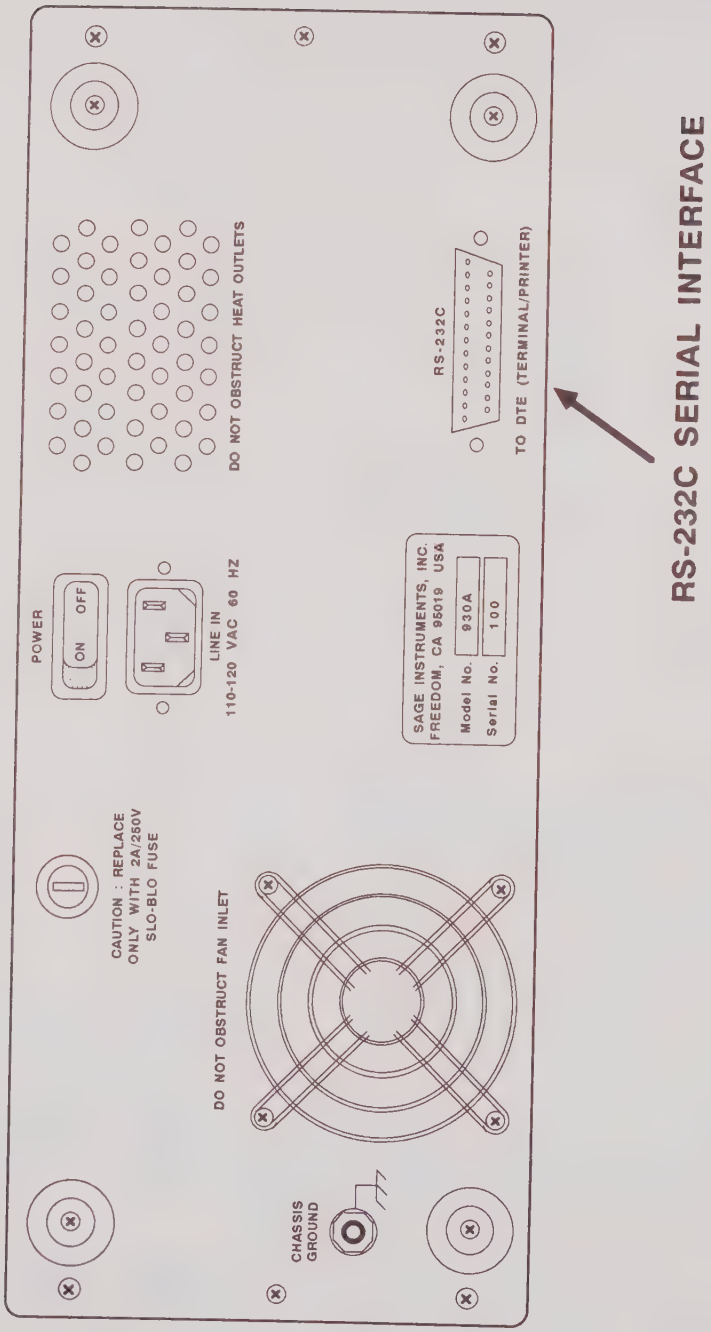
The ON/OFF switch controls power to the 930A. It is located at the top center of the rear panel as shown in Figure 2-4. The AC power connection is located directly beneath the ON/OFF switch and is intended for use only with the power cord supplied with the unit.

The fuse holder is spring loaded and access to the fuse is by inserting a flat blade screwdriver into the fuse holder slot and making a 1/4 turn counterclockwise. The fuse is a 2 Amp Slow-Blow. If a power surge causes the fuse to fail, be sure to replace it ONLY with a fuse of the same rating, and ONLY after determining that the condition which caused the failure no longer exists.

The fan grill allows access for cooling air into the Model 930A. Do not block the air intake, place it adjacent to a heating duct, or operate the unit standing on it's rear panel on a thick carpet. Holes drilled in the upper right side of the rear panel are intended for the exit of warm air. These should not be blocked either or damage to the Model 930A may result.

The rear panel plastic feet support the 930A on a level surface for operator convenience. DO NOT place an operating 930A on thick carpets or on surfaces that are thick with dust as access to the fan grill may be blocked.

The grounding lug, located at the lower left edge of the rear panel, provides ready access to the Model 930A's case ground for safety purposes.



MODEL 930A REAR PANEL
FIGURE 2-4

The RS-232C connector (Option 930A-10C) when present, is located at the lower right side of the rear panel. The connector is configured internally as Data Communication Equipment (DCE). This enables direct connection to Data Terminal Equipment (DTE) such as terminals or printers. However, connection to a MODEM (DCE) must be made through a "null modem" adapter cable.

CAUTION

The rear panel is held in place by four screws.
DO NOT REMOVE THEM
Access to the interior of the Model 930A is
provided by removing the top cover.

The top cover of the 930A case is secured by four 3/8 inch Phillips head screws. Removing these screws allows the cover to be lifted off, giving access to the interior. Figure 2-5 shows the interior of the Model 930A.

At the rear of the interior is a gold anodized box which contains the power supply.

WARNING

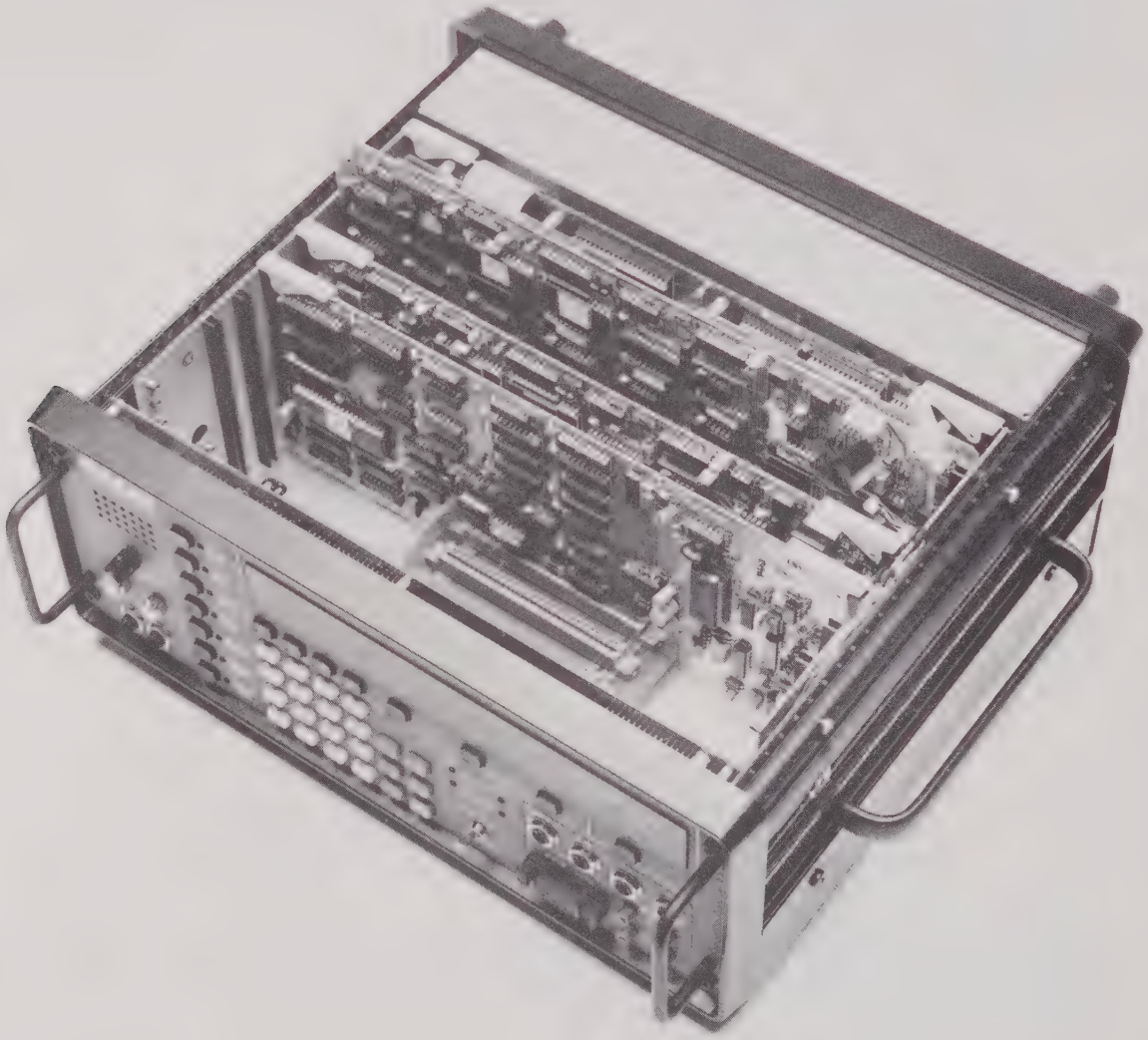
DO NOT ATTEMPT TO OPEN OR REMOVE THIS BOX
Doing so will expose the user to dangerous voltages.

The power supply is a 115 VAC line switching supply. It is intended for connection to standard U.S. line outlets and provides -48 V., +/- 15 V., and +5 V. internally.

There are seven PC Card slots inside the case. Some or all of these will be filled with cards depending upon options installed. The common cards for all units include a CPU card, a Digital Signal Processing (DSP) card, an AC interface and a DC interface card (Standard Analog access configuration). Other card slots are for options such as one or two PCM cards.

WARNING

DO NOT REMOVE OR INSERT CARDS WHILE POWER IS ON



MODEL 930A INTERIOR VIEW
FIGURE 2-5

The user may have occasion to remove a card from the Model 930A. Remove any attached cables from a card before attempting to remove the card.

Cards are removed by means of the extractors built into each card. The small white plastic handles in each corner of the cards are the extractors. To remove a card, grasp the extractor handles and pull straight upward in an even motion.

When reinserting cards, they should enter their slots with an audible and tactile snap. Be sure that the cards are returned to their correct slot and that all connecting cables to the cards have been correctly restored before applying power. Partially inserted boards will be damaged if power is applied.

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SECTION III
OPERATION

3-1 INTRODUCTION

This section of the manual provides the user with information on operation of the Model 930A to test in analog and digital communications networks. The Model 930A is a general purpose test set which has been designed to test Equal Access (Feature Group D), DS-1, PBX, Data, Toll, Message and Private Line trunks. The Model 930A is particularly well suited to testing at the local DEMARC or at the Point of Interface (POI).

3-2 OPERATING CHARACTERISTICS

The Model 930A performs the three basic functions required of a DEMARC test set in today's environment. These are: Transmission Measurements, Signaling and Supervision, and DS-1 PCM Drop/Insert (optional) testing.

The Model 930A has been designed to access and perform tests on the following types of circuits:

Equal Access (Feature Group D)
Centralized Automatic Message Accounting (CAMA)
Traffic Service Position System (TSPS)
Toll
International Direct Distance Dialing (IDDD)
Data
PBX
Private Line Automatic Ringdown (PLAR)
Manual Ringdown (MRD)
Foreign Exchange Office and Station ends (FXO/FXS) (optional)
DS-1 PCM TX/RX (Half-Channel) (optional)
DS-1 PCM Dual Direction Drop/Insert (optional)

The Model 930A can simulate the telephone company central office as well as the terminating end of the circuit, be it customer provided equipment, an Inter-LATA carrier, or DEMARC or Point of Presence.

The transmission measurements which the 930A can make are:

1. Level and Frequency
2. Noise (C-MSG, C-Notch, 3 KHz Flat and Signal to Noise)
3. Noise to Ground
4. Noise with Tone
5. Return Loss (2-Wire and 4-Wire)
6. P/AR (optional)
7. 3-Level Impulse Noise (optional)
8. Phase/Amplitude Jitter & Hits (optional)
9. 4 Tone Intermodulation Distortion (optional)
10. Envelope Delay Distortion (optional)

The signaling and supervision simulation capabilities of the Model 930A are:

1. 2 and 4 wire Loop Start (Normal and Reverse)
2. Ground Start (Normal and Reverse)
3. E&M signaling Types I, II, III, IV and V
4. Wink Start `
5. Multi-Wink/Multi-Stage (Feature Group D)
6. Delay Dial
7. SX supervision
8. DP, DTMF, and MF signaling
9. DP, DTMF, and MF receiver/analyzer (option 930A-01)
10. SF supervision (option 930A-02)
11. DS-1 (Robbed Bit signaling) (option 930A-08 or -09)
12. FXO/FXS supervision (option 930A-25)

In addition to its supervisory signaling simulation capabilities, the Model 930A can establish the talk condition for transmission testing and has the ability to hold circuits for testing.

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MODEL 930A FRONT PANEL
FIGURE 3-1

3-3 INITIAL TURN-ON PROCEDURE

After reading Section 2-3 of this manual, the operator is prepared to turn on the Model 930A. When first switched on, the 930A should briefly display the following:

where "N.NN" is the version of software present in the unit. Note the condition of the eleven LED's on the front panel. If a normal "Warm Boot" has occurred then one LED will be lit or flashing. If an error has been detected by the built-in self test, all of the LED's will be lit, and the unit will perform a "Cold Boot". This is an abnormal condition indicating a possible malfunction of the test set. Turn unit off and perform a "Cold Boot" as described on page 3-6.

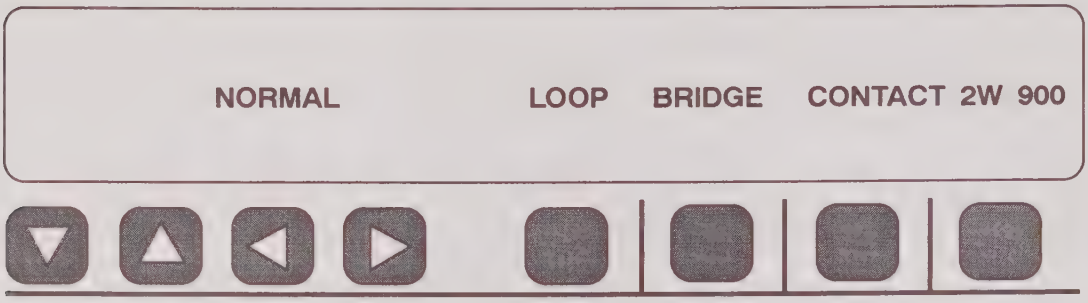
The seven black keys arranged in a column along the left edge of the panel are the Function keys. There is an LED for each key to indicate which function is in use. The Send Tone LED flashes when the 930A is sending tone.

Refer to Figure 3-1 for the locations of the LED indicators and Function keys.

Once the unit has been turned on (regardless of whether a Warm or Cold Boot has occurred) the 930A will display the Trunk Type menu. This is the starting point for any testing.

If a Warm Boot has taken place, the display will return to the Trunk Type that it was in when the unit was turned off or experienced a momentary power loss. All settings and program storage locations will be exactly as they were since they are stored in battery backed CMOS RAM.

In the event of a Cold Boot, the 930A will reinitialize itself to factory settings. The Trunk Type display will then read:



indicating a loop trunk expecting normal Battery/Ground supervision, with the 930A in a bridging mode, ready to supply contact, and a two-wire 900 ohm configuration. Remote control will be off. Storage locations will have been cleared and reset to their factory defaults.

The user may force a Cold Boot if it is desired to return the unit to factory settings. To accomplish this it is necessary to turn the unit off and then, WHILE HOLDING DOWN ANY ONE OF THE SEVEN FUNCTION KEYS, switch the unit ON. CONTINUE TO HOLD DOWN THE FUNCTION KEY UNTIL THE DISPLAY HAS SCROLLED COMPLETELY ACROSS THE SCREEN. Check the LED's (all on) to confirm a Cold Boot. After a Cold Boot the 930A display should be as shown above. This procedure is not advised unless the user is prepared to accept the loss of any stored test programs since a Cold Boot erases user programs and replaces them with factory defaults.

Under normal circumstances, the Model 930A will power up exactly as it powered down, with all settings and storage locations intact. If power was interrupted while in a Remote Control mode, the unit remains in that mode when power is restored. The Model 930A will continue in the same trunk type it was in prior to the power loss. All commands will be processed normally after power has been restored.

The Model 930A is now ready to use.

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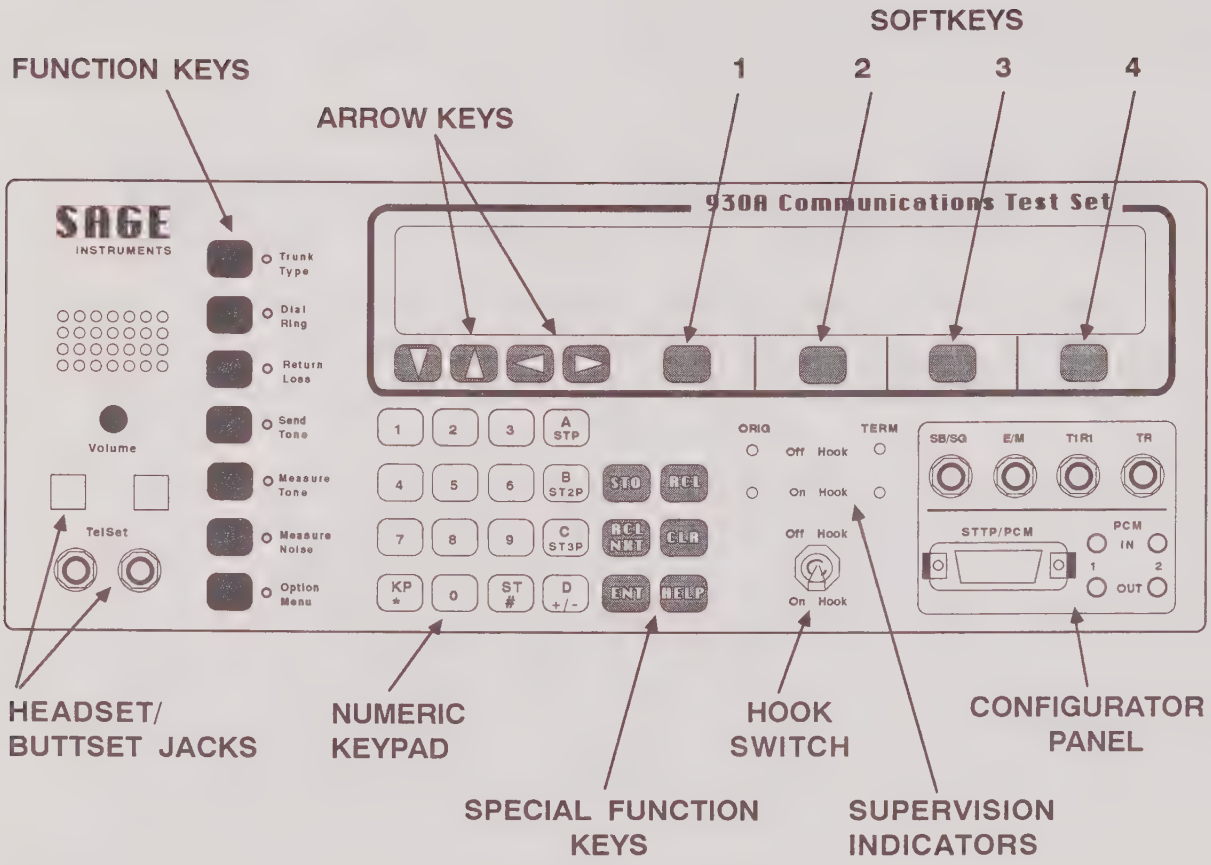

FRONT PANEL LAYOUT
FIGURE 3-2

3-4 FRONT PANEL CONTROLS, INDICATORS, AND CONNECTORS

The front panel layout with location of the controls, indicators, and connectors is shown in Figure 3-2.

3-4.1 DATA ENTRY

Data entry on the Model 930A may be accomplished in one of three ways: Numeric entry using the Numeric Keypad; Menu entry using the Soft Keys; or Incremental entry using the Cursor or Arrow Keys.

3-4.2 USING THE NUMERIC KEYPAD

The Numeric Keypad consists of the sixteen white keys located directly beneath the left hand corner of the display as shown in Figure 3-2 and in the diagram below.

When entering numerical data such as Tone Frequency or Level, the user will generally be prompted by a flashing cursor as to the digit location and number of digits expected by the unit. Once the correct numerical values have been selected, data entry is accomplished by pressing either the ENTER key (See Section 3-4.3.4) or any of the Softkeys. Any leading blanks (digits expected but not entered) are treated as zeroes. The sign of signed numbers may be changed by pressing the +/- key.

AS LONG AS THE CURSOR IS DISPLAYED, NUMERICAL INPUT IS EXPECTED. The Model 930A will accept numeric data or the +/- (change sign) key in this mode. Input may be terminated by pressing the ENT key, any Softkey, or any Function key. The following example illustrates use of the Numeric Keypad.

EXAMPLE:

Press the Option Menu key. The most recent Menu selection used will be displayed. Press any Numeric Key. A two digit flashing cursor will appear with the number displayed as the least significant digit (pressing ENTER or any Softkey now will enter a one digit number). If a second digit is entered from the numeric keypad the first digit will be displaced to the left. If the first digit was "1" and the second was "2" then a "12" would be displayed. Keying in more digits will displace those already entered. This allows input to be corrected until ENTER, or any Softkey, is pressed.

The main exception to the previous example is the entry of the strings of digits for outpulsing in the DIAL/RING Function, which will be explained later. In this case no cursor is displayed. The +/- (also labeled "D") key will outpulse the DTMF ("D") tones. Entry may be interrupted or terminated by the user at any time without pressing ENTER.

3-4.3 USING THE SPECIAL FUNCTION KEYS

The six light grey keys located to the right of the Numeric Keypad are the Special Function keys. In many ways the operation of the Model 930A is similar to that of a pocket calculator. This is nowhere more apparent than in the use of the Special Function Keys. The keys and a brief description of their functions follows. More detailed descriptions are contained in sub-sections 3-4.3.1 to 3-4.3.4.

- The **STORE** key is used to store a particular test setup, outpulse sequence, digit string, or any parameters into one of the forty register locations (01 to 39). This is done by pressing the STO key, entering the two-digit number corresponding to the register location desired, then pressing the ENT key.

- The **RECALL** key is used to recall a test set-up or other parameters which have been stored in a particular register. For example, if the user had stored a DTMF sequence in register 28, then to recall the sequence it would be necessary to press RCL, then enter a "2" and an "8" from the numeric keypad and press ENT. Program 28 will then be recalled.

- The **RECALL NEXT** key is a handy way for the operator to sequentially step through a number of stored programs. For example, a user has a sequence of ten tests stored for routining a switch, starting at register location 16. Press "RCL 16 ENT" to begin testing and then press "RCL NXT" to go to Program 17 and so on.

- The **CLEAR** Key is used to clear or initialize sequences and allow new entries to be made. It is not used to clear a numeric value to zero. This is done by simply entering a zero. The CLEAR key is used to clear sequences of variable length, such as a string of digits to be outpulsed.

- The **ENTER** key operates exactly as many calculators function. Once the correct numeric data has been input for a particular test or program, it is necessary to press ENTER.

- The **HELP** key is provided to assist the user in operating the Model 930A. Any time the user gets stuck, pressing the HELP key provides a series of screens which will generally lead the operator step by step through the function.

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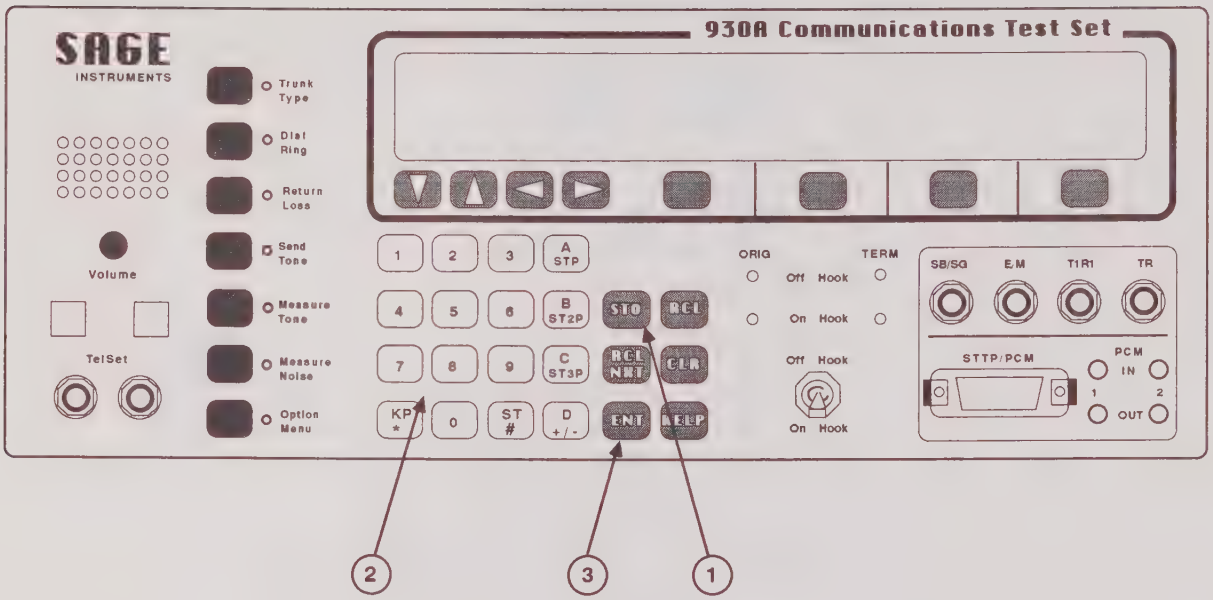


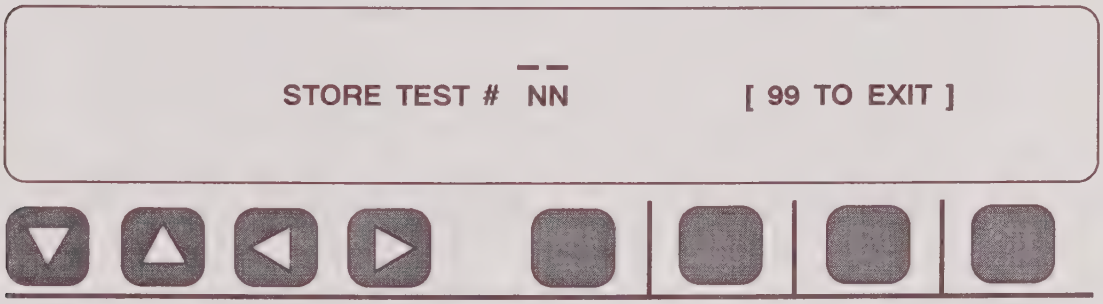
To Store a Test Set-Up or Function in Memory:

1. Press the key labeled STO (Store).
2. Enter the number (01 to 39) of the memory location program is to be stored under.
3. Press the key labeled ENT (Enter) to complete storage.

STORING A FUNCTION
FIGURE 3-3

3-4.3.1 STORE

The 930A has the capability to store up to forty (01-39) test set-ups in battery backed CMOS RAM. Once stored they remain available even after accidental or intentional power losses. The user may change them easily by storing a new set-up into memory on top of the old set-up. Storage is into a numbered location in test memory. The STO key may be pressed at virtually any point in the operation of the Model 930A. Refer to Figure 3-3 for key locations and step by step procedure. The following display will be presented to the operator after pressing the STO key:



where " NN " is the number of the storage location. If the location number displayed is acceptable, press the ENTER key or any Softkey. If another memory location is desired, simply use the numeric keypad to enter the correct number and then press ENTER or any Softkey. To exit without storing anything simply enter "99" and press ENTER.

All test memory locations are functionally identical so any location can be used. However it is generally a good idea to use consecutive storage locations for related test set-ups. Note that the Model 930A automatically increments the storage location after each entry. The user may make consecutive stores by simply pressing STO and ENT.

Any given storage location may be used any number of times. Storing something new at a location automatically replaces the previous contents. Exactly what gets stored depends upon what the Model 930A is doing when the STO key is pressed. A general description of the stored parameters for various test situations follows:

> **In Trunk Type:** all of the trunk type parameters listed on the display are saved exactly as they are shown. For PCM trunks this includes the undisplayed parameters set in the sub-menu.

In Dial/Ring: the displayed digits, the outpulsing mode (MF, DTMF, or DP), AND ANY MODIFICATIONS made in Modify Send Digits (Option Menu #1) are saved. If a digit string has been stored with modifications (see Section 3-12.1) the outpulsing label ("MF", "DTMF", or "DP") will be preceded by the ">" character.

In Return Loss: all of the displayed parameters including signal type, echo-suppress tone, and trans-hybrid loss are saved.

In Send Tone: the level, frequency, and Tone On/Tone Off are saved.

In Measure Tone: the relative zero level is saved.

In Measure Noise: the filter type, balanced or noise to ground measurement and relative zero are saved.

NOTE: In any measurement function, it is the test set-up (parameters) which is saved, NOT THE CURRENT MEASUREMENT RESULTS.

To store a set-up from within the Option Menu, EXIT TO THE OPTION MENU by pressing the Option Menu key. All parameters of the menu selection (whose name and number are displayed) can then be saved using the STO key. The only exception to this is Modify Dial/Ring (Option Menu # 1). Parameters set in Modify Dial/Ring are considered to be undisplayed parameters of the Dial/Ring Function and are saved with Dial/Ring.

It is not possible to use STORE from within a HELP screen or sub-menu nor is it necessary. All parameters set within a sub-menu or HELP screen can be saved with their parent function. Attempts to use STORE when it is not possible will produce no visible effect.

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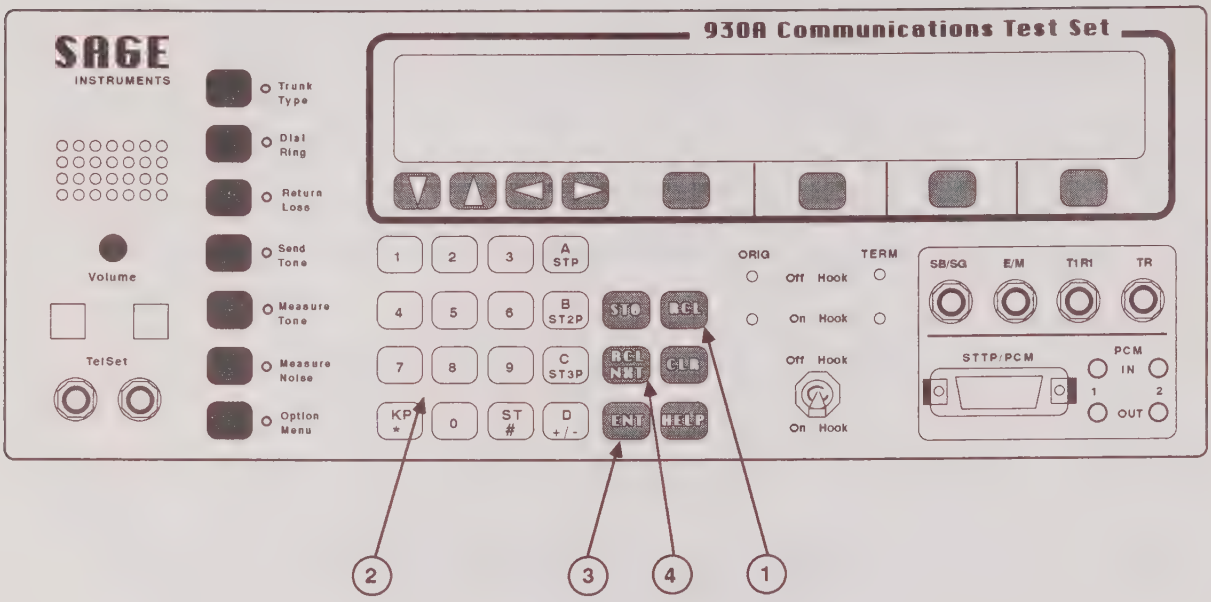


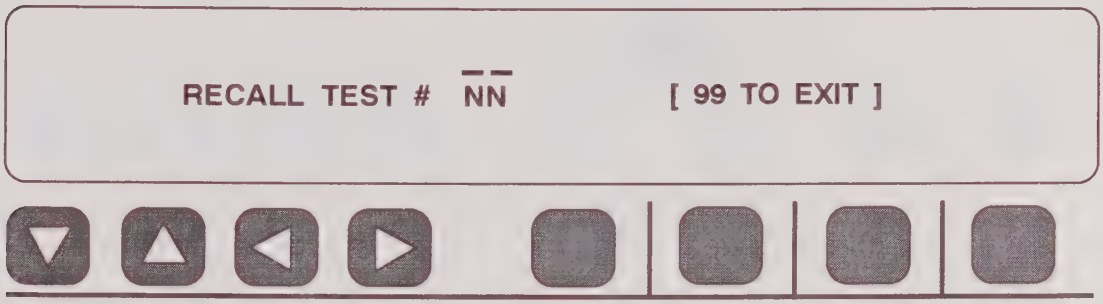
To Recall a Test Set-Up or Function from Memory:

1. Press the key labeled RCL (Recall).
2. Enter the two digit number of the location in memory where the program is stored.
3. Press the key labeled ENT (Enter) to retrieve the program.
4. Press the key labeled RCL NXT (Recall Next) to recall the next program sequentially (i.e. program 03, then 04, etc.)

RECALLING A STORED FUNCTION
FIGURE 3-4

3-4.3.2 RECALL AND RECALL NEXT

Refer to Figure 3-4 for key locations and step by step operating instructions for the Recall and Recall Next functions. Pressing the RCL (RECALL) key will bring up the following display on the Model 930A:



Use the numeric keypad to input the number (between 01 and 39) of the storage location of the desired test set-up. Press ENTER or a Softkey to recall the set-up stored in that location. A "set-up" by definition means one of the Model 930A's functions (or Option Menu Selections) with its parameters set to their stored values. The Model 930A returns to the function it was in when STORE was pressed and restores the relevant parameters to those which were selected at that time.

Any stored set-up can be recalled by the following sequence; Press RECALL, then select the number of the appropriate storage location (01 to 39), then press ENTER or any Softkey. To exit without recalling a set-up simply input "99" and ENTER.

Pressing the RECALL NEXT key recalls the next consecutive test location without requiring the operator to input a number. This convenient feature enables the operator to rapidly step through a series of related test set-ups with very few key strokes. Using this feature, tests set up by one person can be recalled and run by less skilled personnel, or even a computer, with relative ease. Test sequences for pre-service testing of Digital Channel Banks, Transmultiplexers, Digital Switches, and PBX's are easily stored and can be uniformly performed by any level of personnel. What is recalled will depend upon what was stored. For a description of what is stored when the STO key is pressed, review Section 3-4.3.1.

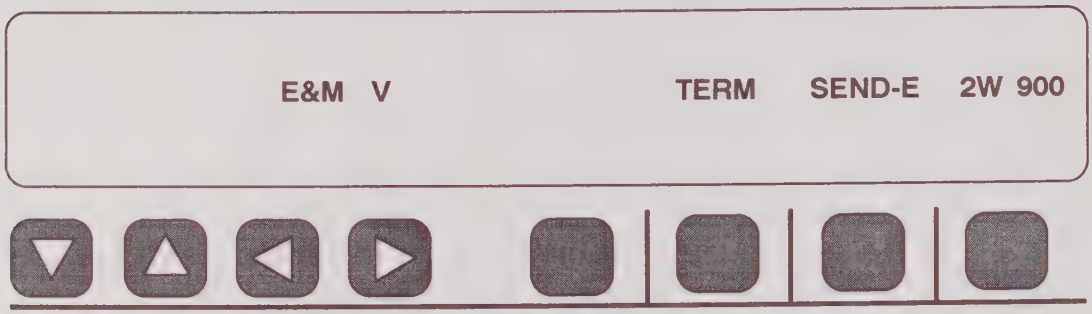
> **NOTE:** If a "Cold Boot" is performed, all storage locations will be cleared. Recalling a blank location brings up the Measure Tone function.

The following simple example will serve to illustrate the use of the STORE, RECALL, and RECALL NEXT keys:

EXAMPLE: One way to measure the loss on a line with the 930A is to perform the following steps:

Press the **Trunk Type** function key.

The 930A display will appear somewhat like the following display depending upon the trunk type selected:



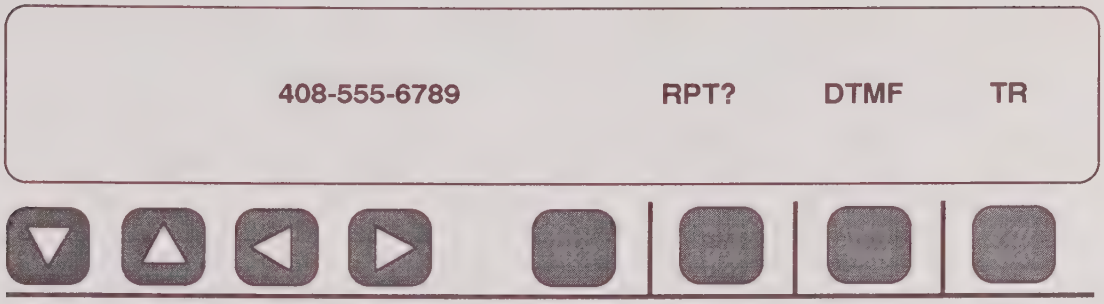
Set up the trunk type to the correct condition (assume that the above displayed trunk type information is correct for this example) and store it in register location 1.

Press the STORE key, then press and then the key.

Press the DIAL/RING **Dial/ Ring** function key.

Go "Off Hook" by placing the Hook Switch in the OFF HOOK position and enter the telephone number of the local milliwatt test line using the numeric keypad. The 930A will dial the number as it is entered.

An example 930A display follows:

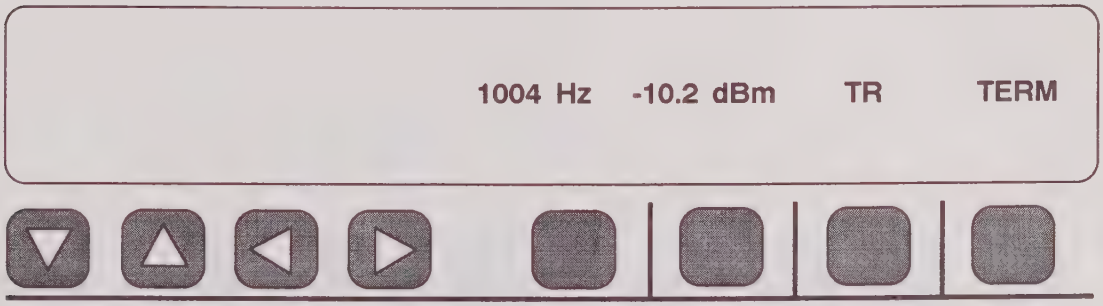


Store the test line phone number in register location 2.

Press the STORE STO key and then the ENTER ENT key.

Press the Measure Tone Measure Tone function key.

Measure the level being sent when the tone is audible.
A typical 930A display is shown below.



Store the Measure Tone Function set up in register location 3.

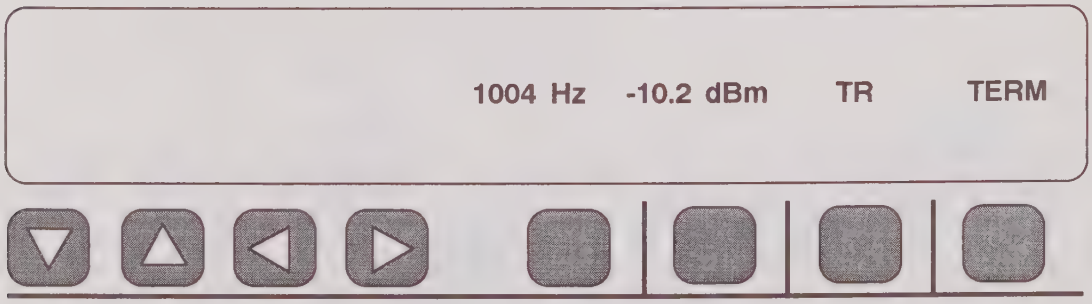
Press the STORE STO key and then the ENTER ENT key.

The test has now been performed and the test sequence has also been stored. The entire test can now be rerun at any time with only six simple keystrokes as shown on the next page.

To rerun the test sequence in the previous example follow the steps below.

STEPS	PRESS KEY	DESCRIPTION
1	RCL	
2	1	
3	ENT	Recalls Trunk Type Set-Up
4	RCL NXT	Recalls Milliwatt Number
5	SOFT KEY 2	Places the Call
6	RCL NXT	Calls Up Measure Tone

The displayed measurement is the loss on the line. A typical display of measured tone would appear somewhat like that shown below:



Remember that in order to outpulse the phone number, the 930A Hook Switch must be placed in the OFF HOOK position to seize the line and draw dial tone. Then pressing Softkey 2 labeled "RPT?" will outpulse the digit string.

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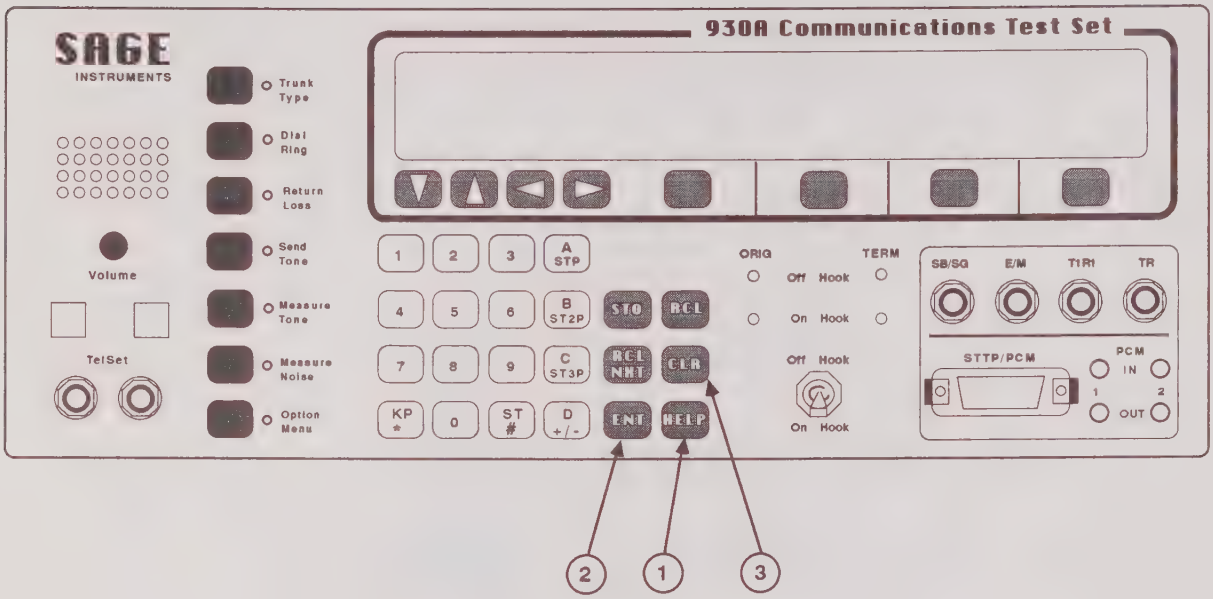


To use the HELP, ENTER or CLEAR keys:

1. Press the key labeled HELP for step by step instructions of set-up procedures for any of the function keys except the Option Menu key. The set-up selections are made using the Softkeys under the display.
2. Press the key labeled ENT (Enter) to complete a numeric entry.
3. Press the key labeled CLR (Clear) to clear out or initialize a sequence as in DIAL/RING mode. It does NOT clear numeric values to zero.

USING THE HELP KEY
FIGURE 3-5

3-4.3.3 THE HELP KEY

The HELP key is provided to assist the user during operation of the 930A. Refer to Figure 3-5 for the location of the HELP key and a step by step procedure for its use. Any time that the operator encounters difficulty in setting up or using the 930A, pressing the HELP key will provide a series of screens and menu choices. These will take the operator step-by-step through the parameters that need to be selected for the current function. This simplifies set-ups by providing the user with one clearly defined choice at a time until all of the choices have been made.

The HELP screens provide the answers to the most common user questions. For example, if the HELP key is pressed during numeric data input, the user will be prompted to press ENTER to proceed.

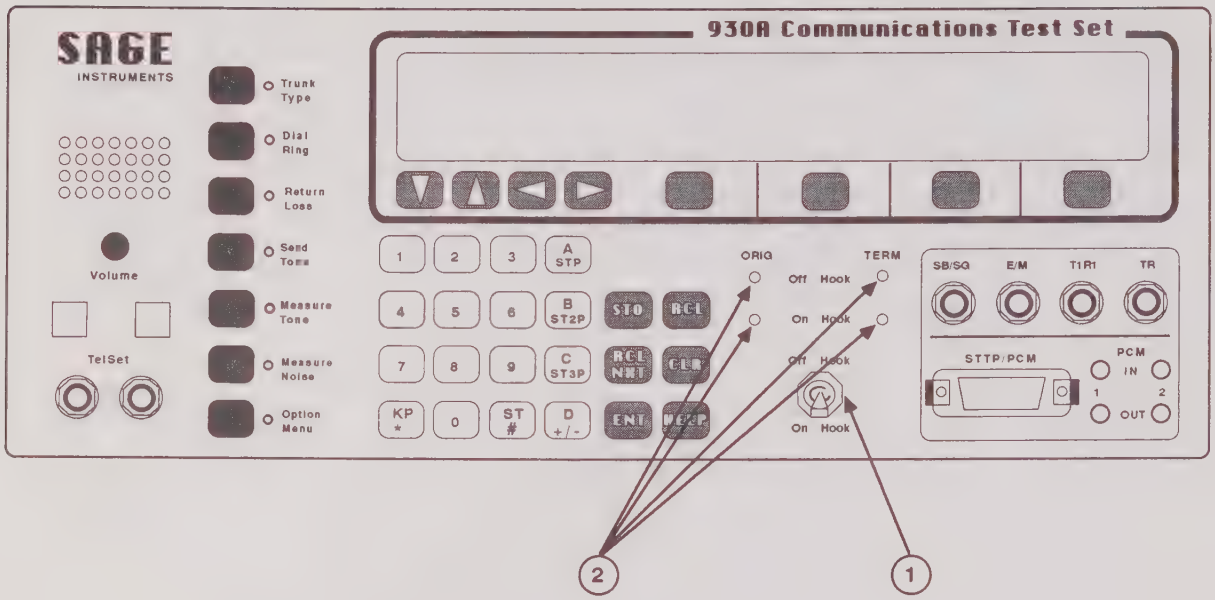
3-4.3.4 ENTER AND CLEAR

Refer to Figure 3-5 for the location of the Enter and Clear keys.

The ENTER key is used to indicate completion of numeric entry. Any time the value of a parameter is input numerically, it is necessary to press ENTER (or any Softkey) to terminate input and "enter" the number.

The CLEAR key is used to clear or initialize sequences and allow new entries to be made. It is NOT used to clear a numeric value to zero. This is done by simply entering a zero. The CLEAR key is used to clear sequences of variable length, such as a string of digits to be outpulsed.

The only functions which require the use of the CLEAR key, and which are covered in this manual are, Dial/Ring (Section 3-7), Multiple Records (Section 3-12.2), and Receive Records (Section 4-2).



To use the Hook Switch:

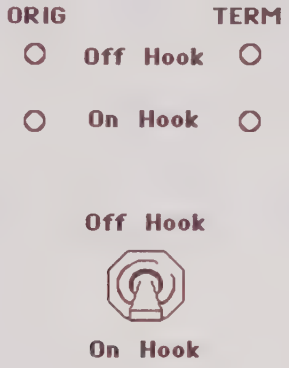
1. The Hook Switch controls whether the 930A is "On-Hook" or "Off-Hook". On 2- and 4-wire analog trunks it also engages the holding coils (To outpulse digits, send tones, etc. the 930A must be "Off-Hook").*
2. The Supervision LEDs show the status of the Originate and Terminate ends of the circuit.

* In some Trunk Types and directions (such as Loop Contact) the 930A must be "Off Hook" to send tones and outpulse digits.

USING THE HOOK SWITCH
FIGURE 3-6

3-4.4 USING THE HOOK SWITCH

The chrome switch located to the right of the Special Function keys as shown in Figure 3-6 is the Hook Switch. The four LED's above the Hook Switch are the Supervision Lamps.



A WORD ABOUT SUPERVISION:

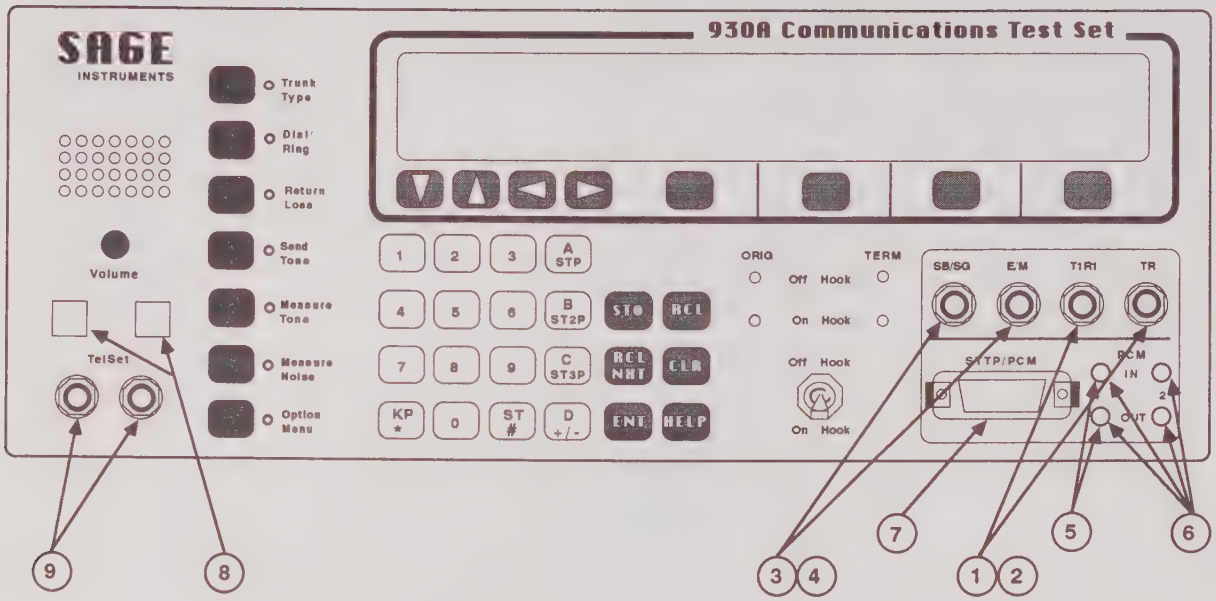
The Supervision Lamps are labeled "ORIG" and "TERM". The 930A is obviously the "Originating" end of the circuit when sending digits. The 930A is necessarily the "Terminating" end when receiving digits. In certain applications it is less obvious which end is "Originating" and which is "Terminating". An example of this might be Foreign Exchange circuits. By convention, then, the "ORIG" lamp always shows the 930A's status, unless receiving digits.

The Hook Switch is labeled "ON HOOK" and "OFF HOOK". In order to send a string of digits it is necessary to go "OFF HOOK". This is identical to the procedure employed when placing a regular telephone call. The telephone handset must first be picked up (Going Off Hook) before the number can be dialed. Going "ON HOOK" is the same as hanging up the telephone and terminating the call.

NOTE:

If the Model 930A has been placed in a REMOTE CONTROL mode of operation, the Hook Switch will be inoperative.

The operation of the Hook Switch on PCM trunks is described in Section 4-6.



Test Cord connections to the 930A:

1. 2-Wire metallic access uses the type 310 jack labeled "TR".
2. 4-Wire trunks use the 310 jacks labeled "TR" and "T1R1".
3. E&M Type I trunks use the 310 jack labeled "E/M" as well as the TR and T1R1 jacks.
4. E&M Types II, III and IV use the SB/SG jack as well as the other three jacks.
5. Single direction T-1 testing uses the PCM IN 1 and OUT 1 jacks.
6. Dual direction T-1 testing uses PCM IN 1 and 2 and PCM OUT 1 and 2.
7. The 15 pin connector is used with Options 930A-14 and 930A-114 to provide a direct interface to a No. 1/1A ESS machine.
8. Connect Lineman's Butt-Set to the Butt-in connectors.
9. Connect Telephone Headset or Handset to the TelSet jacks.

CONNECTION OF TEST CORDS
FIGURE 3-7

3-4.5 TEST CORD CONNECTIONS TO THE 930A

Connection of test cords to the 930A is accomplished at the configurator panel located in the lower right hand corner of the front panel as shown in Figure 3-7.

Several types of configurator panels are available depending upon the options installed in the 930A. Refer back to Figure 2-3, page 2-6 for a description. Although the jacks may be located in different positions, a jack labeled "TR" for example, is connected and used the same on all configurator panels.

Figure 3-7 shows the connection points for the various test cords which may be used with the 930A. The universal configurator is shown because it has the most varied connections.

As shown, a 2-wire Loop Start, Ground Start, or Reverse Battery trunk is connected to the 930A at the type 310 jack labeled "TR".

A 4-wire trunk requires connections to the type 310 jacks labeled "TR" and "T1R1". Also, if the trunk is an E&M trunk, the E&M lead test cord must be connected to the type 310 jack labeled "E/M". Further, if E&M Types II through IV are being tested, then the signal battery/signal ground leads must be connected to the type 310 jack labeled "SB/SG".

If a T-1 (DS-1) carrier circuit is to be tested then the tiny telephone (bantam) jacks labeled "PCM IN 1" and "PCM OUT 1" are used for single direction and out of service testing. This requires Option 930A-08 or -09 to be installed.

If dual direction drop and insert testing is to be performed or, if dual direction in-service monitoring is desired, then all four bantam jacks must be connected.

Diagrams of the test cord connections for PCM trunk testing are shown in Section 4 in Figures 4-7 through 4-11.

If the 930A is to be used to directly interface to a No. 1/1A ESS switching machine at the local trunk test panel, then the Sage Model 114A adapter is wired into the trunk test panel and the 930A is connected to the 114A by a special cable using the 15 pin connector labeled "STTP/PCM".

If the operator desires to place a call using the 930A or to talk over the trunk under test then a telephone handset or lineman's butt-in set may connected to the TelSet jacks or the butt set terminals located in the lower left hand corner of the front panel.

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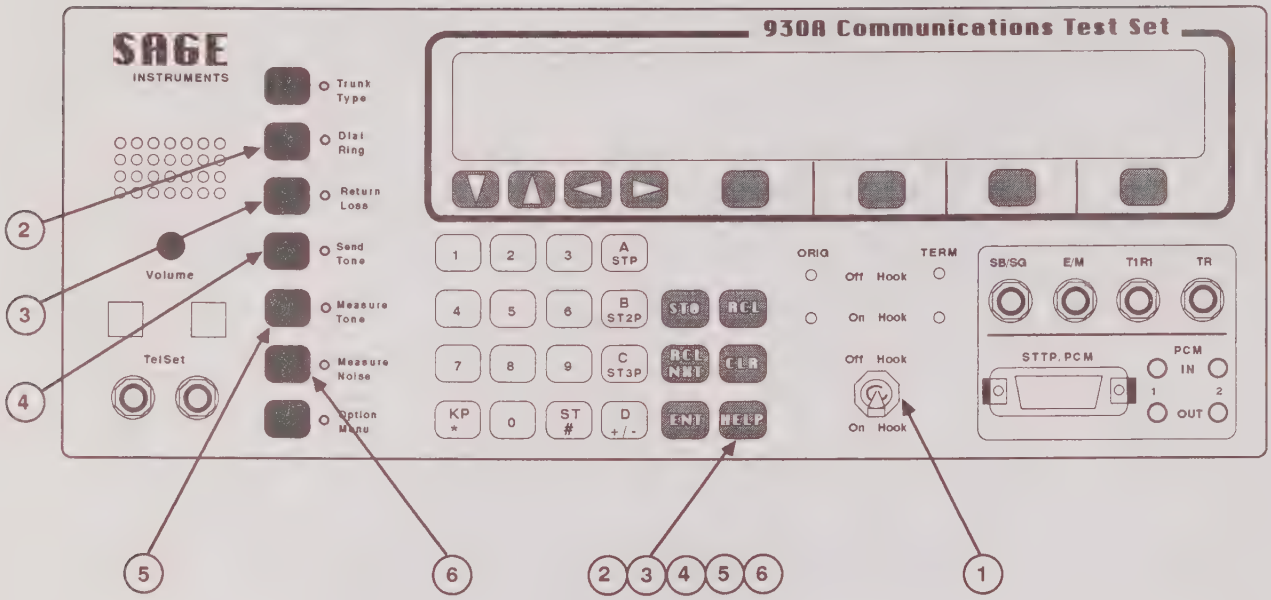


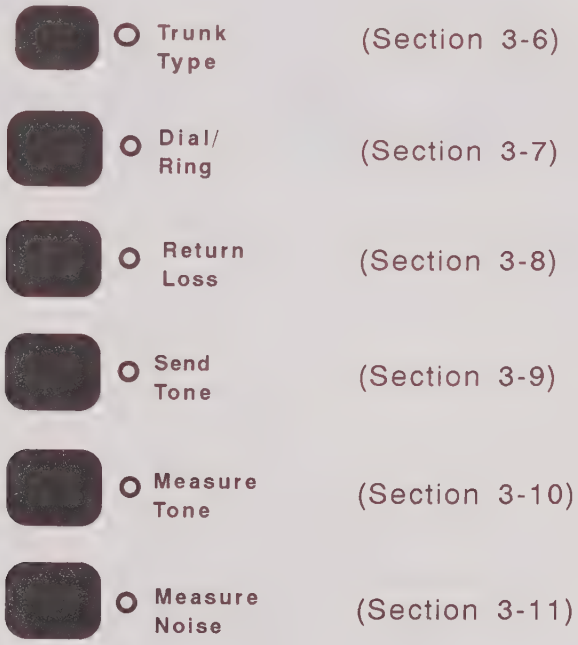
Some commonly performed tests are:

1. After selecting the correct trunk type, place the Switch Hook in the OFF HOOK position to draw Dial Tone.
2. To place a call, press the DIAL/RING function key. Press the HELP key if unsure of operation.
3. To measure Return Loss, press the RETURN LOSS function key. Press the HELP key if unsure of operation.
4. To Send a frequency at a specific level, press the SEND TONE function key. Press HELP if unsure of operation.
5. To measure the frequency and level of a received tone, press the MEASURE TONE function key.
6. To measure the noise level on a circuit, press the MEASURE NOISE function key. Press the HELP key if unsure of operation.

COMMONLY PERFORMED TESTS
FIGURE 3-8

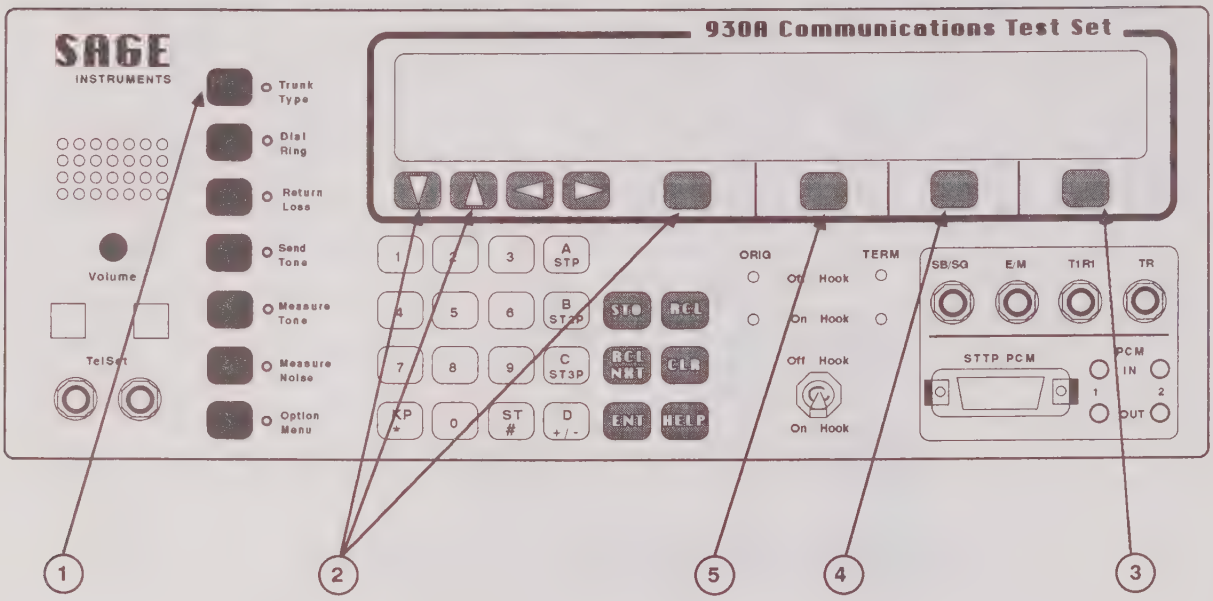
3-5 BASIC FUNCTIONS

The six basic functions built into all Model 930A's are controlled by the vertical row of FUNCTION Keys located on the left side of the Model 930A front panel as shown in Figure 3-8. There are seven Function keys: one for each of the six basic functions and an "Option Menu" key for additional functions and future expansion of capabilities. The six basic functions covered in the following sections are:



Six additional functions are included as standard equipment with the Model 930A.

These functions, accessible under the "Option Menu" key, are: Modify Send Digits, Send Multiple Records, Wink Timing, Frequency Sweep, Adjust TLP and Beep On Error. These functions are described in Section 3-12.



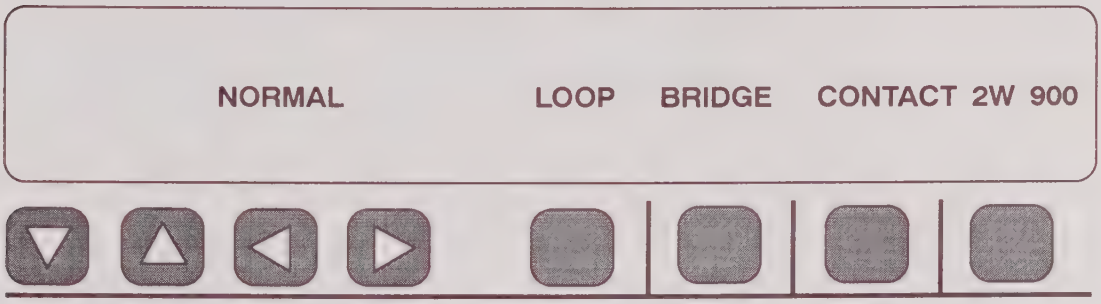
To Select and Set-Up the Trunk Type:

1. Press the TRUNK TYPE function key.
2. Use the UP/DOWN arrow keys or Softkey 1 to scroll through and select the desired trunk type.
3. Press Softkey 4 to select 2-wire or 4-wire operation and the appropriate impedance (150, 600, 900 or 1200 ohms)
4. Press Softkey 3 to select the correct simulation for the testing direction (BATTERY to simulate the Central Office toward the subscriber loop, CONTACT to simulate the subscriber toward the Central Office, SEND-M to be the Originate office or SEND-E to be the Terminate office).
5. Press Softkey 2 to select TERMinated or BRIDGEd operation as appropriate.

SET-UP OF TRUNK TYPE
FIGURE 3-9

3-6 TRUNK TYPE FUNCTION KEY

Pressing the Trunk Type function key will cause the 930A to display the current trunk type and configuration in use. A typical display is shown below:



When power is first applied to the 930A it will default to the Trunk Type function. The appropriate Trunk Type must be selected before any testing can begin. Refer to Figure 3-9 for step-by-step set-up procedure.

3-6.1 STANDARD TRUNK TYPES

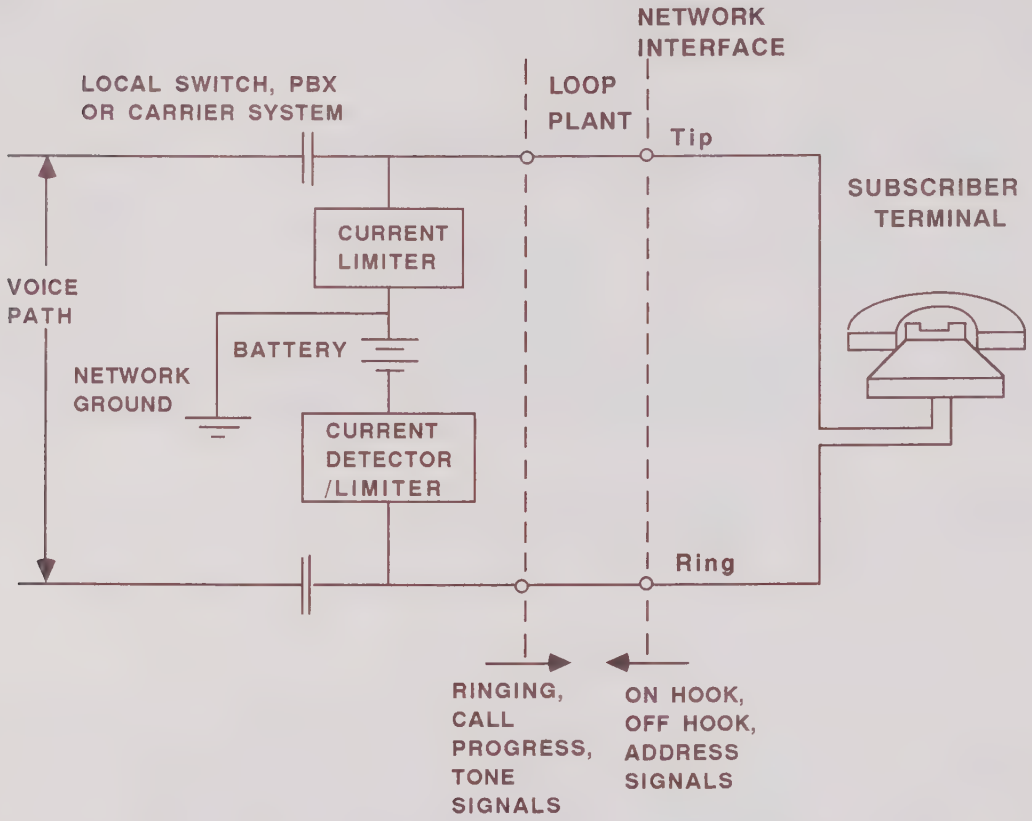
The basic Model 930A is equipped to operate with Loop Normal, Loop Reverse, Ground Start (Normal and Reverse), and E&M (Types I-V) supervision. The Model 930A can simulate either the Central Office or PBX end of the circuit in TERMINATE mode. The 930A can passively monitor both ends of a circuit in BRIDGE mode.

Supervision notifies the central office switch or PBX that the subscriber is requesting service. This is accomplished when the subscriber picks up the telephone handset from the cradle and thereby goes "Off Hook". It is also used to alert the subscriber to incoming calls. There are a number of supervision types available but the most common ones in use are those provided by the Model 930A. These are Loop Start, Ground Start, Reverse Battery, and E&M Types I, II and III. Each of these types of supervision are described below.

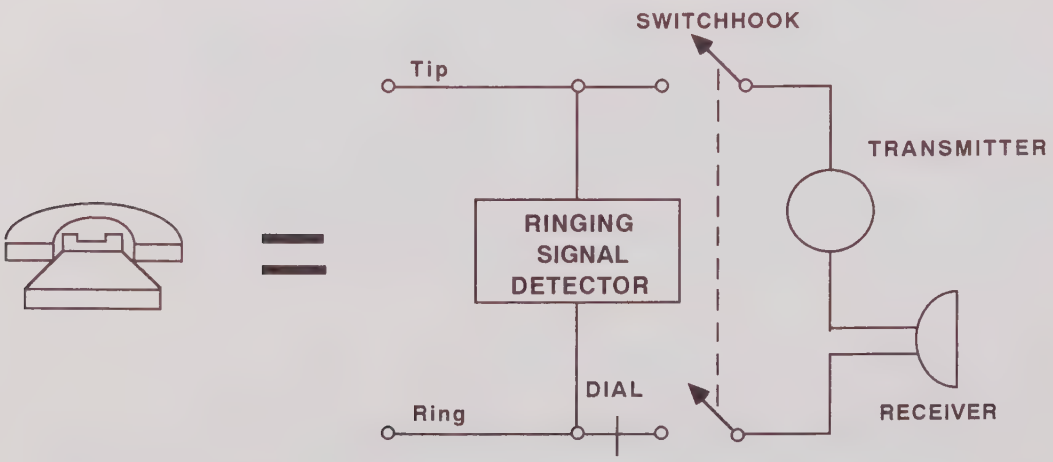
3-6.1.1 LOOP START SUPERVISION

Loop Start supervision is the most common form of supervision found in the subscriber loop. Public telephone service, PBX trunks and a majority of special services trunks use Loop Start supervision.

The diagram below illustrates the principle of operation of Loop Start supervision.



The subscriber terminal itself has an equivalent circuit as shown below:



LOOP START SUPERVISION CIRCUITS

The terminal appears as an open circuit to the network while On-Hook. To initiate a call the terminal must go Off-Hook and an Off-Hook signal is sent toward the network by lowering the tip to ring DC resistance to a value at or below 330 ohms and drawing a DC current from the network. The network detects this current as a seizure signal or request for service and responds by sending back a dial tone signal which is an AC signal superimposed on the DC current. The most common DC voltages found on Loop Start trunks range from 48 to 55 Volts although voltages as high as 105 Volts or as low as 0 Volts may be encountered. Higher voltage is an indication of loop extension equipment on the line.

The service is called Loop Start because a loop closure is required for seizure. Once the loop is closed the DC current has a path to ground and can flow. The flow of DC current is an indication of loop closure and request for service.

The 930A can emulate either the Central Office end of the circuit or the Subscriber. To simulate the Office, the 930A should supply BATTERY. To simulate the subscriber the 930A should supply CONTACT. These functions are selected by Softkey 3 when the 930A has the Normal Loop trunk type selected and displayed.

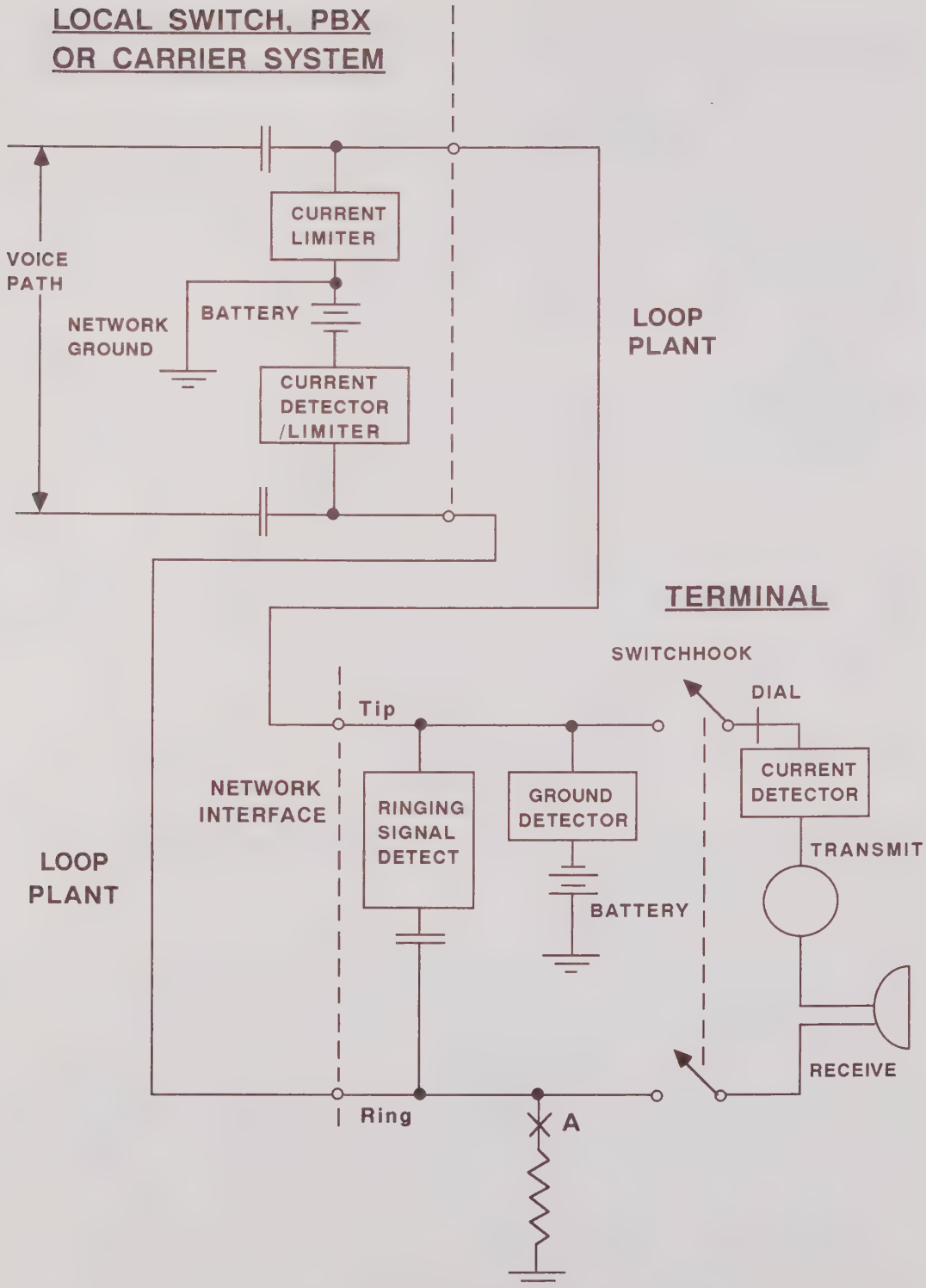
3-6.1.2 GROUND START SUPERVISION

Ground start supervision for 2-way dial facilities was introduced to reduce the chance of seizure of the facility by both ends of the circuit during the silent interval between rings.

Ground start supervision is commonly used on trunks between PBXs and a Central Office. Ground Start is also used on Automatic Call Distributor trunks and trunks used for automatically originated data services.

The 930A can emulate either the originate end or the terminate end of the circuit. Usually the PBX end is the originate and the Central Office is the terminate end. After selecting Ground Start trunk type on the 930A use Softkey 3 to select BATTERY (Terminate) or CONTACT (Originate).

The principle of operation of a Ground Start circuit is shown in the following illustration.



GROUND START SUPERVISION CIRCUIT

In the On-Hook state, the terminal presents an open circuit from tip to ring and ring to ground. The terminal has a ground detector connected tip to battery to detect an Off-Hook or seizure from the network. To initiate a call, the terminal grounds the ring side of the line by operating contact A. The resulting current flow through the resistor is detected by the network. The network then applies the positive side of the battery to the tip side of the line. This grounds the tip side of the line. The terminal detects the ground on tip through the ground detect circuit and responds by closing the switchhook contacts and opening contact A. The terminal is now in the loop mode.

Once in the loop mode everything operates as it did for the Loop Start trunks.

Ground Start lines are used in place of Loop Start lines for the following reasons:

1. A signal is provided that can act as a start-dial signal so that it is not necessary to detect dial tone.

2. Ground Start provides a positive indication of a new call.

3. Prevents unauthorized calls.

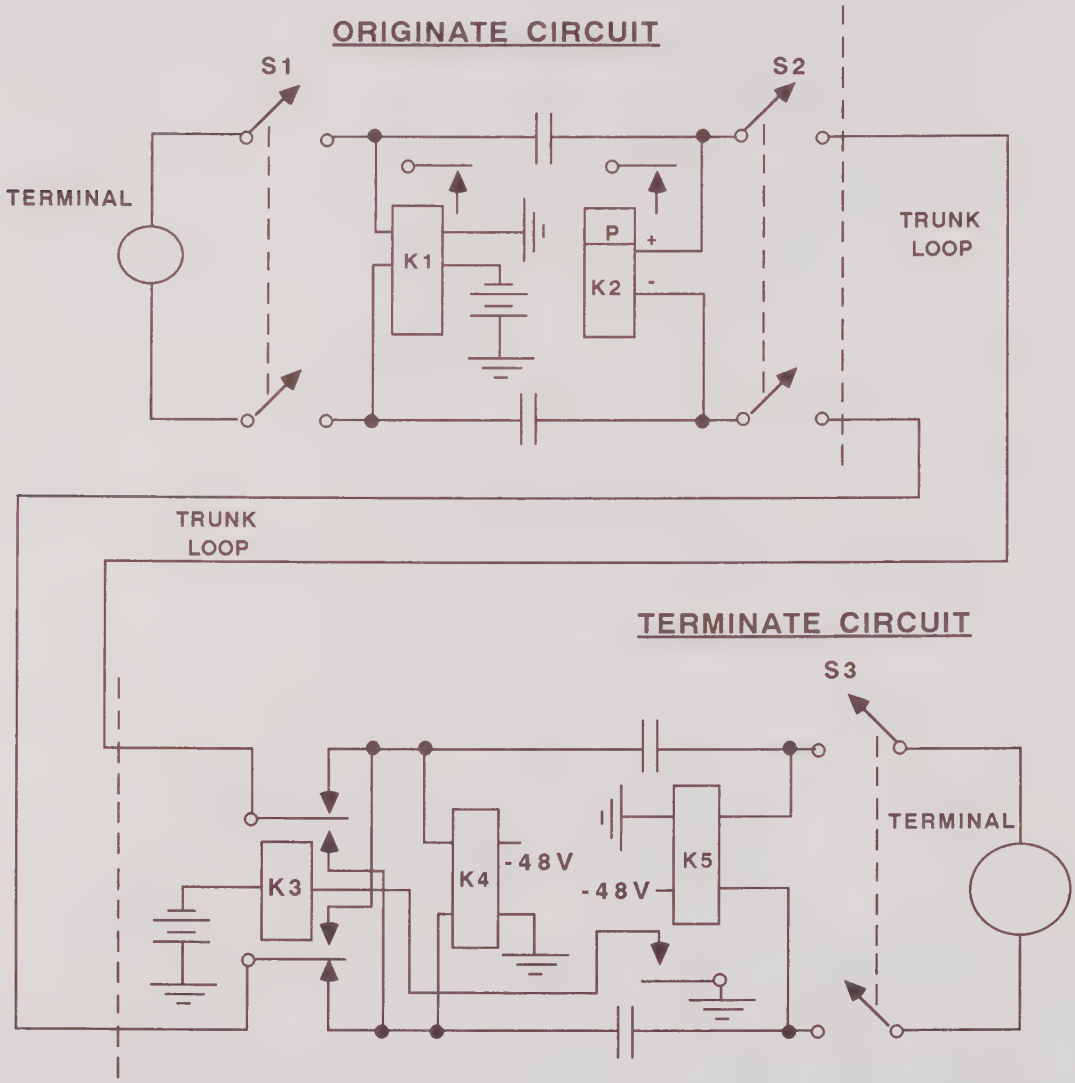
4. Provides indication to calling or called party of distant end disconnect under normal operation.

3-6.1.3 REVERSE BATTERY SUPERVISION

Reverse battery supervision may use either the Loop or Ground Start methods previously discussed. It gets its name from the fact that battery and ground are reversed on the tip and ring to change the signal toward the calling end from On-Hook to Off-Hook.

Loop Reverse Battery supervision is used on one-way trunks such as Direct Inward Dial lines on PBXs. This permits an outside call to directly dial a PBX subscriber extension without operator assistance. The call can only be initiated from the originate end of the circuit hence the designation one-way trunk. However, once the call has completed, normal two-way communication is carried. The term one-way trunk applies only to the supervision and not to communication.

The following illustration shows reverse battery supervision applied between offices in a common control arrangement.



REVERSE BATTERY SUPERVISION

In the On-Hook condition shown, all relays are inactive and all switches are open. When the outgoing trunk is seized by the originating office, switches S1 and S2 close thereby completing the loop to the terminating office and causing relay K4 to operate. Operation of K4 signals an Off-Hook indication to the terminate office. After the digits have pulsed from the originate office to the terminate office, switch S3 closes and the called party is alerted. When the call is answered, relay K5 operates.

Operation of relay K5 causes relay K3 to operate which reverses the polarity of the voltage on the loop to the originate end. This in turn causes polarity sensitive relay K2 to operate which sends an Off-Hook or answer signal to the calling party.

The 930A has reverse battery capability on Loop and Ground Start trunks. The most commonly used is Reverse Loop supervision. A typical example is Direct Inward Dial trunks on PBXs which use Reverse Battery supervision.

3-6.1.4 E&M SUPERVISION

Loop Start, Ground Start and Reverse Battery share the trunk loop with the communications path. However, most other forms of supervision are separate from the trunk equipment. These other types are usually located between the trunk equipment and the line facility. The most common form of supervision of this type is called E&M Lead Signaling.

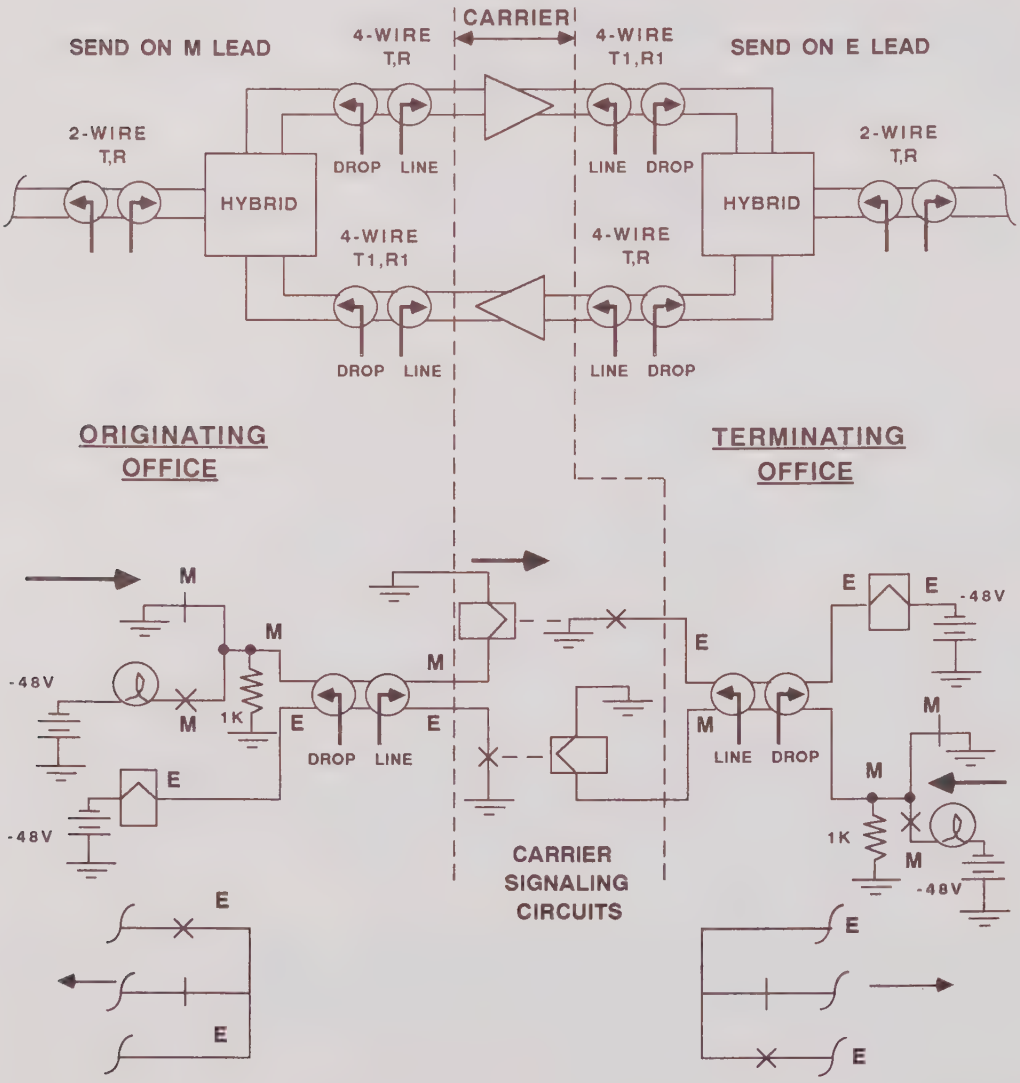
Although no one is quite sure where the E and M designations came from other than historically they were the designations on the drawings they have provided us with a clever way to remember where each is used. If the E lead is thought of as the "Ear" and the M lead is the "Mouth" then we send to the terminate end on the M or Mouth lead and we receive or listen on the E or Ear lead. With the 930A in E&M trunk types, the Originate end of the circuit is simulated by selecting SEND-M and the Terminate end is simulated by selecting SEND-E.

E&M supervision then consists of two leads between the trunk or switching equipment and the signaling equipment. The M lead carries signals from the switch to the signaling equipment and the E lead carries signals from the signaling equipment to the switch.

E&M lead supervision is used extensively on interoffice trunks, signaling the internal switching of PBXs or shorthaul trunks between PBXs.

There are five types of E&M supervision. The most common is E&M Type I. In the U.S. we also use Types II and III. The rest of the world uses the so-called symmetrical Types IV and V.

The following illustration shows a typical E&M Type I application on interoffice trunks.



The basic difference between E&M Type I and the other types is that Types II, III and IV use Signal Battery (SB) and Signal Ground (SG) leads in addition to the E&M leads to improve signaling performance. In some cases the user may also come across E&M Type II, III or IV circuits without access to the SB/SG leads. To facilitate testing, Table 3-1 provides the status of the various leads for either Originate or Terminate conditions.

TABLE 3-1
STATUS OF LEADS IN E&M SUPERVISION TYPES

ORIGINATE (SEND ON M-LEAD)

SUPERVISION	E-LEAD	M-LEAD	SB-LEAD	SG-LEAD
TYPE I	3.3K to B	CLB or G	Open	Open
TYPE II w SB/SG	3.3K to B	SB or Open	M or Open	G
TYPE II w/o SB/SG	3.3K to B	CLB or Open	Open	Open
TYPE III w SB/SG	3.3K to B	SB or SG	M or Open	M or Open
TYPE III w/o SB/SG	3.3K to B	CLB or G	Open	Open
TYPE IV w SB/SG	3.3K to B	SB or Open	M or Open	G
TYPE IV w/o SB/SG	3.3K to B	G or Open	Open	Open
TYPE V	3.3K to B	G or Open	Open	Open

TERMINATE (SEND ON E-LEAD)

SUPERVISION	E-LEAD	M-LEAD	SB-LEAD	SG-LEAD
TYPE I	G or Open	3.3K to G	Open	Open
TYPE II w SB/SG	SG or Open	3.3K to G	CLB	E or Open
TYPE II w/o SB/SG	G or Open	3.3K to G	Open	Open
TYPE III w SB/SG	G or Open	3.3K to G	CLB	G
TYPE III w/o SB/SG	G or Open	3.3K to G	Open	Open
TYPE IV w SB/SG	SG or Open	3.3K to B	G	E or Open
TYPE IV w/o SB/SG	G or Open	3.3K to B	Open	Open
TYPE V	G or Open	3.3K to B	Open	Open

CLB = CURRENT LIMITED -48 V BATTERY ; G = GROUND ; 3.3K to B = 3.3K RESISTOR TO-48 V BATTERY ; 3.3K to G = 3.3K RESISTOR TO GROUND

Where the SB and SG leads are shown OPEN, they are not necessary to testing and the SB/SG jack on the 930A front panel would not be used.

The Type I interface is the original E&M lead arrangement. Supervision from the trunk to the signaling equipment is over the M lead using -48 Volts for an Off-Hook and Ground for an On-Hook indication. From the Terminate end, supervision is sent on the E lead from the signaling equipment toward the switch. The signaling equipment ground is an Off-Hook and an open indicates On-Hook. The full voltage appears on the E lead during the On-Hook state.

The Type II interface is a 4-wire (E&M plus SB and SG leads), fully looped but nonsymmetrical (Originate and Terminate ends are not interchangeable) arrangement. Supervision from the originate end is via opens and closures of the M-lead and SB lead for On- and Off-Hook indications. Since there is -48 Volts on the SB lead, the effect is to signal on the M-lead with battery for Off-Hook and open for On-Hook. From the terminate end, supervision is via opens and closures of the SG and E leads for On- and Off-Hooks. Since the switch grounds the SG lead, the effect is to signal on the E-lead with an open for On-Hook and a ground for Off-Hook.

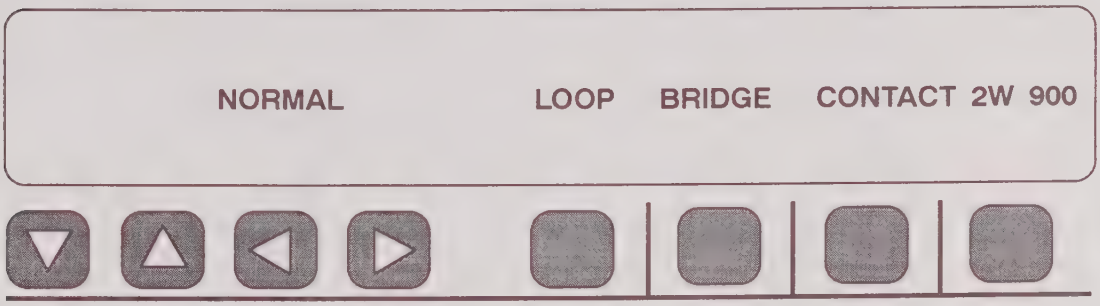
The Type III interface is a compromise, partially looped, 4-wire E&M lead arrangement. It is essentially the same as the Type I interface except that the battery and ground for supervisory signaling on the M lead are supplied by the signaling equipment on the SB and SG leads. The E-lead is identical to the Type I E-lead with the exception that the E-lead current is much lower on Type III interfaces since it is used in electronic switching systems. Type I interfaces used in electromechanical switches require higher E-lead currents.

The Type IV interface is identical to the Type II interface. It is symmetrical and is used on CCITT circuits. It is not usually found in the U.S.

The Type V interface is a symmetrical 2-wire E&M lead arrangement which is the worldwide standard outside the U.S. It is what the rest of the world uses in place of Type I. It is essentially the unbalanced version of Type IV.

3-6.2 KEY FUNCTIONS WITH STANDARD TRUNK TYPES

Pressing the TRUNK TYPE function key will produce a display somewhat similar to the example below depending upon the trunk type previously selected:



The functions of the various front panel keys when TRUNK TYPE has been selected are as follows:

The Numeric Keypad is inactive

The UP/DOWN arrow keys roll through the available trunk types

The Left/Right arrow keys are inactive

Softkey 1 is a wheel selecting trunk type. It has the same effect as the UP arrow key.

Softkey 2 is a wheel selecting Bridged or Terminated operation. When Terminated the 930A simulates one end of a circuit. In Bridge mode the 930A passively monitors the circuit.

Softkey 3 is a wheel selecting which end of the circuit the 930A simulates in the Terminate mode. In Loop or Ground Start this may be either CONTACT (a telephone or PBX) or BATTERY (Central Office). In E&M this may be either Send-E or Send-M indicating which lead the 930A is using to send supervision.

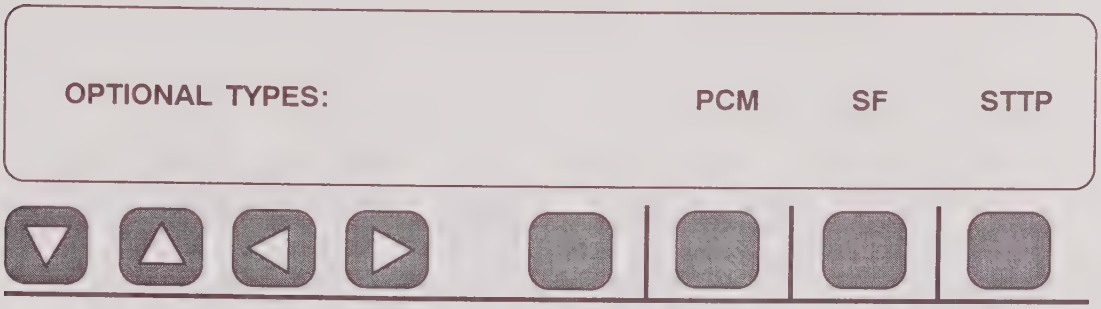
Softkey 4 is a wheel selecting 2 or 4 wire circuits and 150, 600, 900, or 1200 ohm impedances.

NOTE:

Changing trunk types or changing from 2W to 4W operation automatically places the 930A in the BRIDGE mode. In the Bridge mode, the 930A does not send supervision. The Supervision Lamp marked "ORIG" shows the end of the circuit which the 930A would simulate if it were in "TERM" mode.

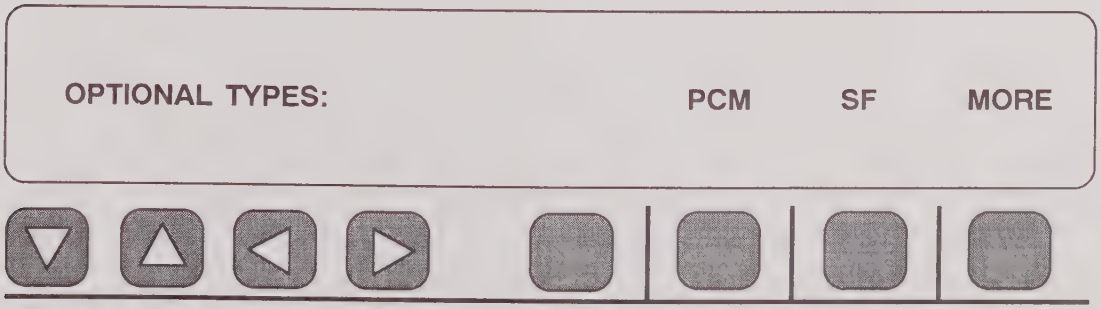
3-6.3 OPTIONAL TRUNK TYPES

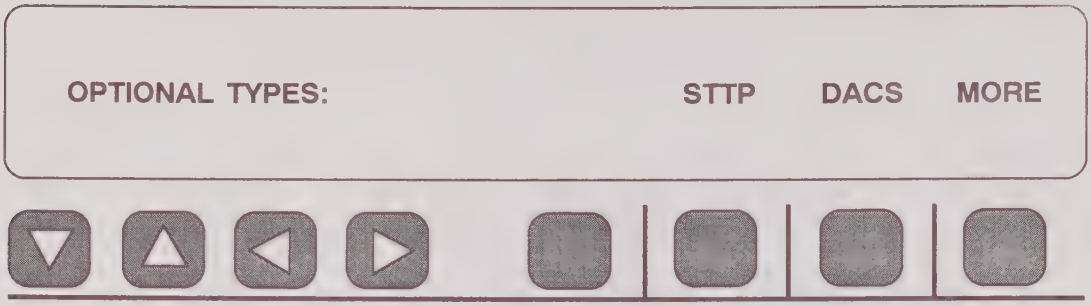
There are several options available for the 930A which expand its capabilities to include testing T-1 (DS-1 PCM) carrier trunks and trunks employing SF supervision. Another option enables the 930A to interface directly with the Secondary Trunk Test Panel (STTP) used with the No. 1 ESS. Pressing the TRUNK TYPE function key will display the current trunk type. Use the UP/DOWN keys to page through the available trunk types until the Model 930A's display is:

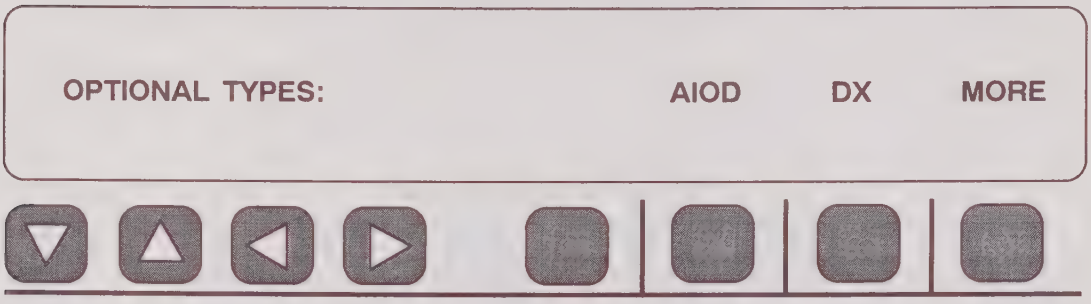


If the options have not been installed in the 930A, attempts to select them will cause the Model 930A to flash a "NOT INSTALLED" message on the display. If any or all of these options have been purchased, then pressing the Softkey located beneath the displayed optional trunk type will cause it to be selected.

Additional optional trunk types which may be added in the future may include DX supervision, Automatic Identified Outward Dial (AIOD) trunks, and DACS Test Port interface. These would be accessed by pressing Softkey 4 which would be labeled "MORE" instead of STTP. The format of the optional trunk type screen would, in effect consists of three screens. That is, the screens would then have the form:







A detailed description of the operation of optional trunk type functions is contained in Section IV.

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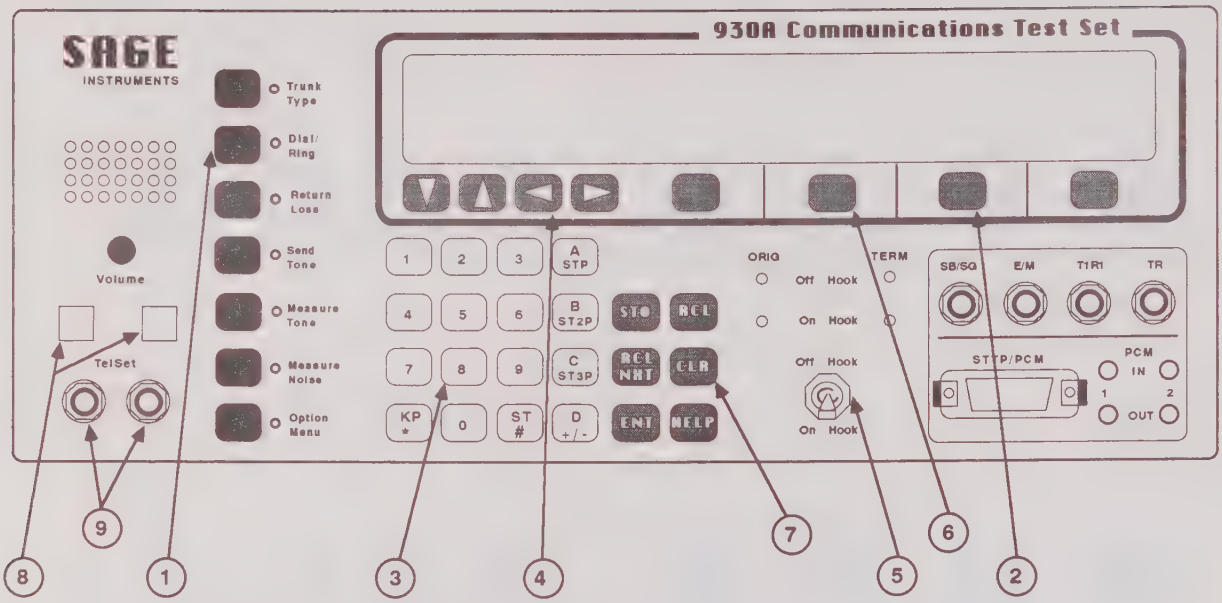


To Outpulse a telephone number and place a call:

1. Press the DIAL/RING function key.
2. Press Softkey 3 to select MF, DTMF or DP as appropriate.
3. Enter the number of the telephone being called using the numeric keypad.
4. If a 1 second pause is desired (To get an outside line at a PBX) press the LEFT arrow key after the digit has been entered (i.e., 9-4087611000).
5. Place the Switchhook in the OFF HOOK position.
6. Press Softkey 2 labeled RPT? to outpulse the digit string.
7. Press the CLR (Clear) key to clear out a sequence before entering a new one.

NOTE: DIGITS ARE OUTPULSED AS THEY ARE ENTERED IF THE 930A IS ALREADY OFF HOOK

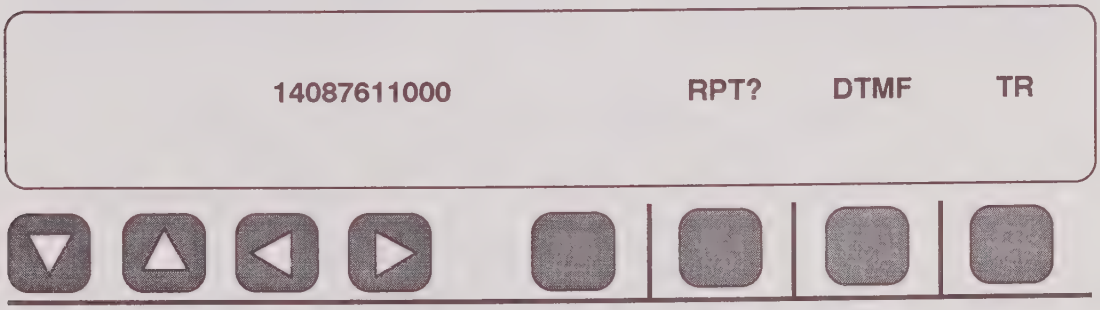
8. To talk over the trunk under test using a Lineman's Buttset, connect it to the terminals shown.
9. If a Central Office headset or handset is available connect it to the TelSet jacks to talk over the trunk under test.

PLACING A CALL
FIGURE 3-10

3-7 DIAL/RING FUNCTION KEY

The Model 930A's front panel controls have been purposely designed for logical operation. After selection of trunk type the next logical step is to have the capability to outpulse a sequence of digits toward the circuit's termination. Refer to Figure 3-10 for key locations and step-by-step operating procedure for placing a call. Refer to Section 4-9 for the optional RING GENERATOR mode of operation.

Pressing the Dial/Ring function key enables the 930A to outpulse digits and also permits the user to talk and listen over the trunk under test. If a digit sequence has been previously entered, the 930A display will show it in the first 18 spaces of the display. The 930A remembers the last number dialed. A typical display for a DTMF (Touch-Tone) digit sequence is shown below:



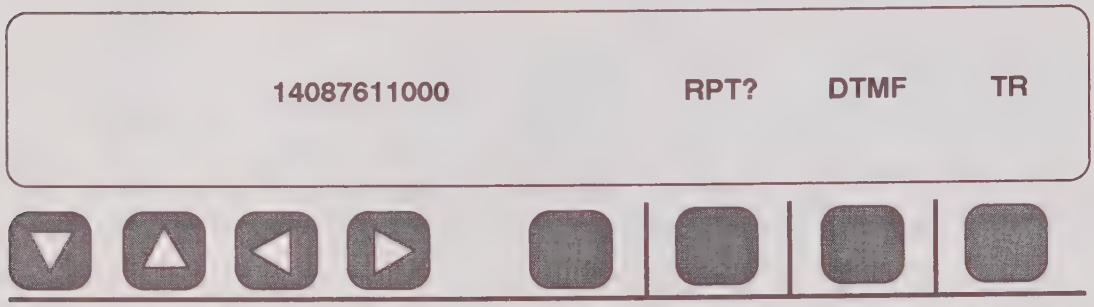
The functions of the various front panel keys when the 930A is in the DIAL/RING mode as shown above are outlined below:

The Left Arrow key is used to insert a one second pause into a digit sequence and appears on the display as a "-" between digits as in "9-14087611000".

Softkey 1 is inactive unless the 930A is in the RING mode (Option 930A-13 has been installed).

Softkey 2, labeled "RPT?", is asking the question, "Do you want to repeat the previously outpulsed digit sequence?" Pressing this key will outpulse the digit sequence currently displayed.

Softkey 3 is a wheel and is used to select either Dial Pulse (DP), Multifrequency (MF), Dual-Tone Multi-frequency (DTMF) or RING (Refer to Section 4-9 for details of the RING mode operation). Dial Pulse is not available when the 930A is simulating a CO (Supplying BATTERY). Changing the outpulsing mode will clear the display of any digit sequence.

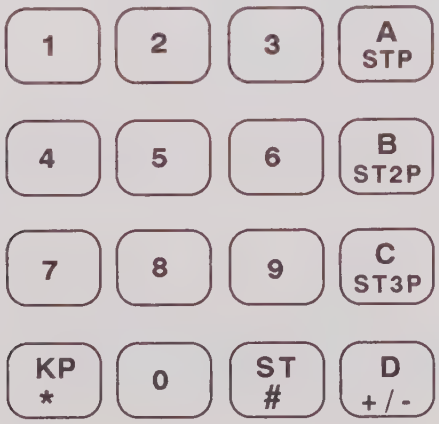


Softkey 4 is inactive. In the display above it indicates which leads are in use for outpulsing (TR, T1R1, Send-E, Send-M, PCM 1 or PCM 2).

The Clear CLR key clears the display and erases any "remembered" digits.

The Enter ENT key is inactive.

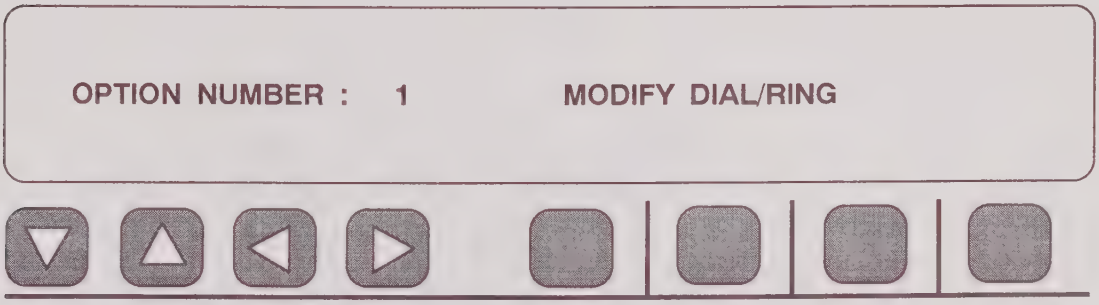
The Numeric Keypad (including the ABCD keys) is the "dialer" and is used to enter digits.



If the Hook Switch is in the OFF HOOK

position, then the digits will be outpulsed as they are entered.

Outpulsing is set to the AT&T standard as the default condition. For example, the MF pulses are 70 milliseconds On and 70 milliseconds Off. The user may modify the level, frequency, and timing of the digits. In order to modify the digits press the OPTION MENU function key. Using the DOWN arrow key, scroll through the menu options to Option 1: MODIFY DIAL/RING. The 930A display should appear as:



Although labeled as an option, these functions should not be confused with purchased options. The MODIFY DIAL/RING function is standard on all Model 930A's.

In either MF or DTMF mode the operator can modify the frequency or level of either or both tones, or the timing.

In Dial Pulse, the operator can modify the % Break, Pulses per second, or the Interdigit Timing.

In all cases a Default setting (AT&T Standard) is available.

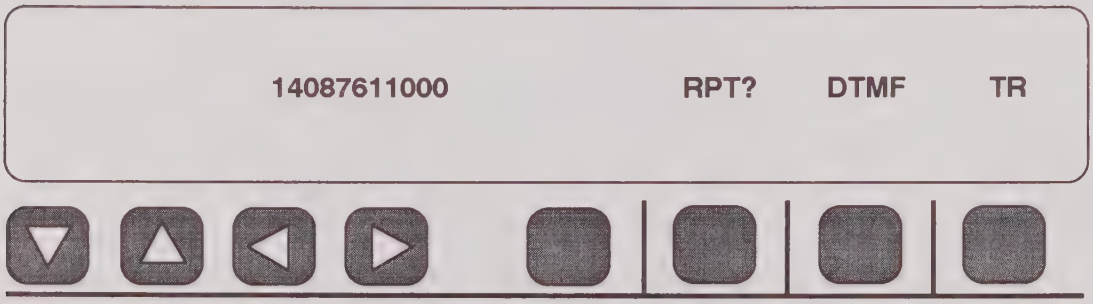
A feature of the 930A, which is included for operator convenience, is an identifier on the display which tells the user that a parameter has been modified. If any of the parameters have been modified from their default values, a ">" marker precedes the outpulse mode identifier above Softkey 3 during operation. For example, a display of a modified MF sequence might appear as:

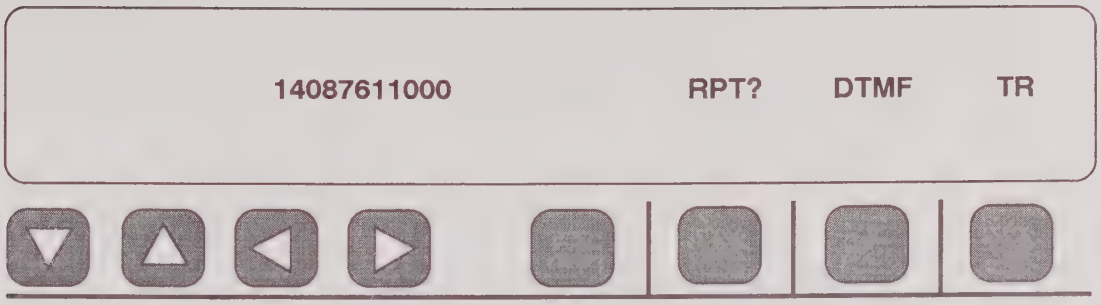
For a detailed description of how to modify the send digits refer to Section 3-12.1.

3-7.1 STORING AND RECALLING DIGIT SEQUENCES

The operator may easily store frequently used digit sequences for future recall and outpulsing. Pressing the STO (Store) key allows the operator to save the currently displayed digit sequence, its outpulsing mode (MF, DTMF, or DP), and any modifications which may have been made using MODIFY DIAL/RING (Option Menu 1). The parameters may be stored in any one of the 40 register locations (numbered from 01 to 39).

For example, suppose it is desired to store the unmodified DTMF sequence, shown in the following display, in register location 17.





To store the DTMF sequence in register location 17, simply perform the following steps:

1. Press the STORE STO key.

2. Press 1 and then 7.

3. Press the ENTER ENT key.

To recall the digit sequence, simply press the RECALL RCL key, then press 1 and 7 then press the ENTER ENT key.

A REMINDER

The recalled digit sequence will set the outpulsed parameters to the values that were set when the digits were stored. Always check for the ">" prompt when recalling digits. Any modifications are available for inspection in MODIFY DIAL/RING (Menu Option 1).

More information on storing and recalling digit sequences with modified parameters is contained in Section 3-12.1. Information on storing and recalling Multi-Wink sequences, such as those found in Equal Access, TSPS, and IDDD applications, is contained in Section 3-12.2.

NOTE:

For IDDD Applications in which a CCITT No. 5 MF sequence is being outpulsed, the required KP2 pulse is equivalent to the ST2P pulse located on the ' B ' key on the 930A's numeric keypad. Such an IDDD MF sequence then would appear as:

ST2P11071738945ST

3-7.2 TRANSMISSION LEVEL POINT (TLP) COMPENSATION

Sometimes it is necessary to adjust the TLP of the 930A when sending or receiving digit strings or when talking or listening on the trunk under test. The 930A default TLP settings normally take care of this automatically when the trunk type is selected. However, in cases where the TLP on the trunk under test is not close to the default TLP settings, the user will note invalid received levels for digits and the audio volume will be off as well. In this case, the 930A enables the user to manually set the TLP level of the instruments transmit and receive sections to compensate. Adjusting the TLP of the 930A has the effect of making the 930A digit receiver either more or less sensitive as required. Digits outpulsed from the 930A are sent at 7 dB per tone below the Transmit TLP (i.e. at a 0 dB TLP the 930A sends individual MF and DTMF tones at -7.0 dBm). A detailed discussion of the TLP Adjustment is contained in Section 3-12.5. The Adjust TLP function is contained in Menu Option 30.

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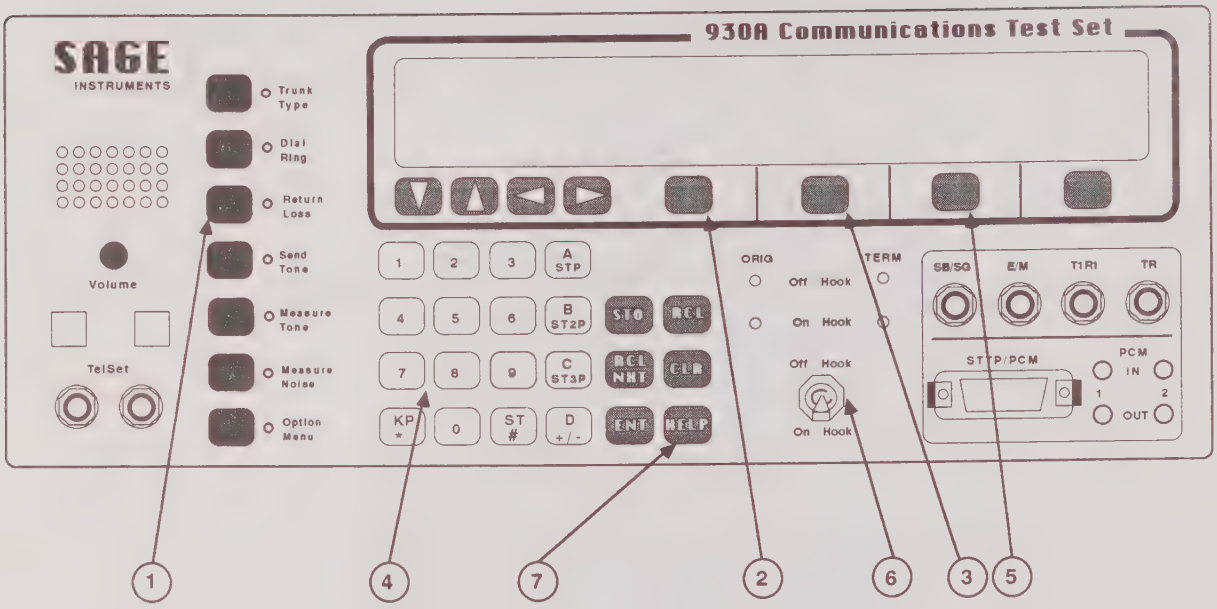


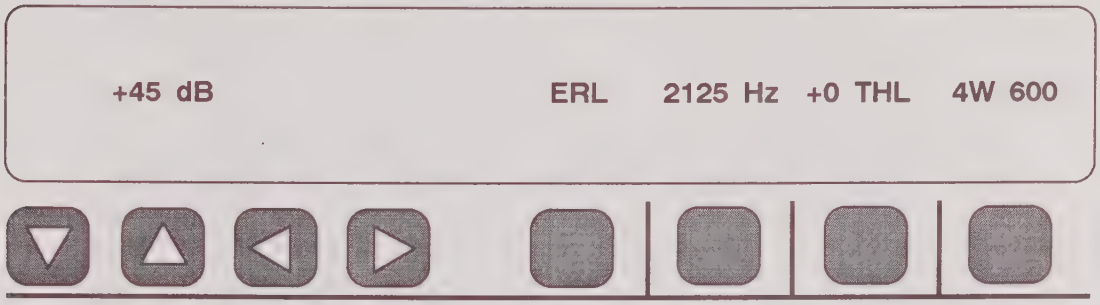
To Measure Return Loss:

1. Press the RETURN LOSS function key.
2. Press Softkey 1 to select ERL, SRL-LO, SRL-HI or Sinewave Return Loss measurement.
3. Press Softkey 2 to send the momentary Echo Suppressor disable tone (2125 Hz) prior to testing.
4. Use the numeric keypad to enter any other disable tone (2000 to 2250 Hz range) or to enter tones for sinewave Return Loss.
5. Press Softkey 3 if required to measure and enter the Trans-Hybrid Loss correction.
6. Ensure that the 930A is OFF HOOK when measuring Return Loss.
7. Press the HELP key if unsure of operation or set-up procedure.

MEASURING RETURN LOSS
FIGURE 3-11

3-8 RETURN LOSS FUNCTION KEY

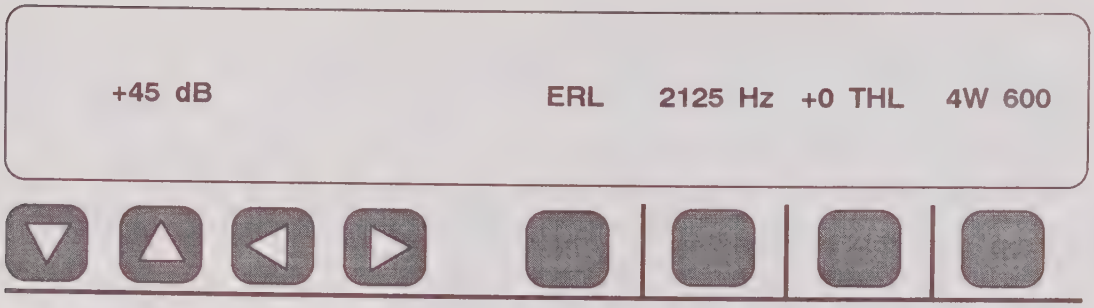
The measurement of Return Loss is an important part of testing a telephone circuit. This measurement function is accessed by pressing the RETURN LOSS Function key which causes the Model 930A to display the last mode of Return Loss measurement which was used. Refer to Figure 3-11 for key locations and step-by-step operating procedure. A typical example of a Return Loss display on the Model 930A is shown below:



The Model 930A is capable of Echo Return Loss (ERL), Singing Low (SRL-LO), Singing High (SRL-HI) and Oscillator or Structural (OSC) Return Loss measurements on both 2-wire and 4-wire circuits. Once the RETURN LOSS key has been pressed, the 930A will begin to send the selected Return Loss signal, and receive and display measurements.

The operation of the front panel keys during Return Loss measurement are as follows:

> Softkey 1 is a wheel allowing the user to select the mode of Return Loss (ERL, SRL-LO, SRL-HI, or OSC), or the type of TR Termination (2 Wire only).

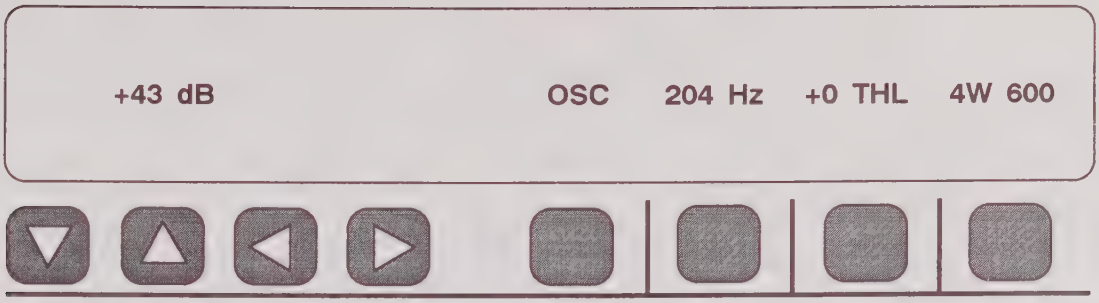


IN ERL, SRL-LO AND SRL-HI:

Softkey 2 sends the echo-suppress tone displayed above it. A common frequency is 2125 Hz but the user should verify the correct value. Use the numeric keypad to enter the correct value of echo-suppress tone.

Softkey 3 is inactive in a 2-wire application. In a 4-wire circuit this key selects Trans-Hybrid Loss (THL) as a parameter to be changed. Pressing this key once will cause the current return loss measurement to be interpreted as the THL. By pressing the key again the measurement is locked in and a flashing cursor appears over the THL. At this point the user may enter a specific THL value using the numeric keypad. Otherwise, pressing ENT or Softkey 3 will lock in the displayed value.

Softkey 4 is inactive. The circuit and impedance are displayed above it. These values are set by the Trunk Type function key discussed in Section 3-6.

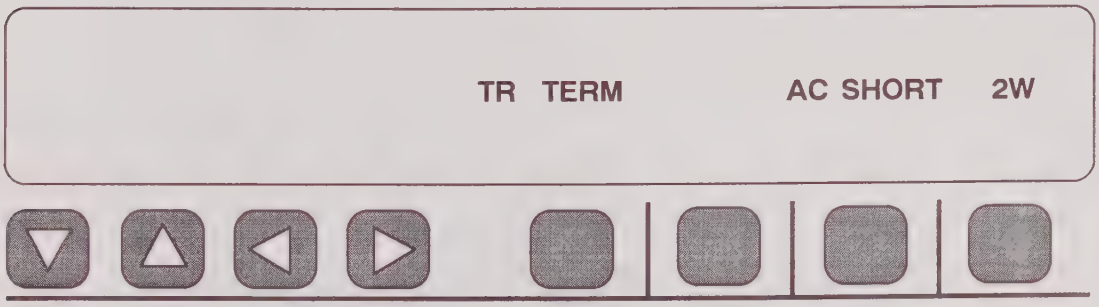


IN OSC (OSCILLATOR OR STRUCTURAL):

Input from the Numeric Keypad modifies the frequency of the tone being sent. Any desired frequency between 20 Hz and 5000 Hz may be entered. The tone is displayed above Softkey 2.

Softkeys 2 and 4 are inactive.

Softkey 3 affects the THL in the same manner as discussed above.



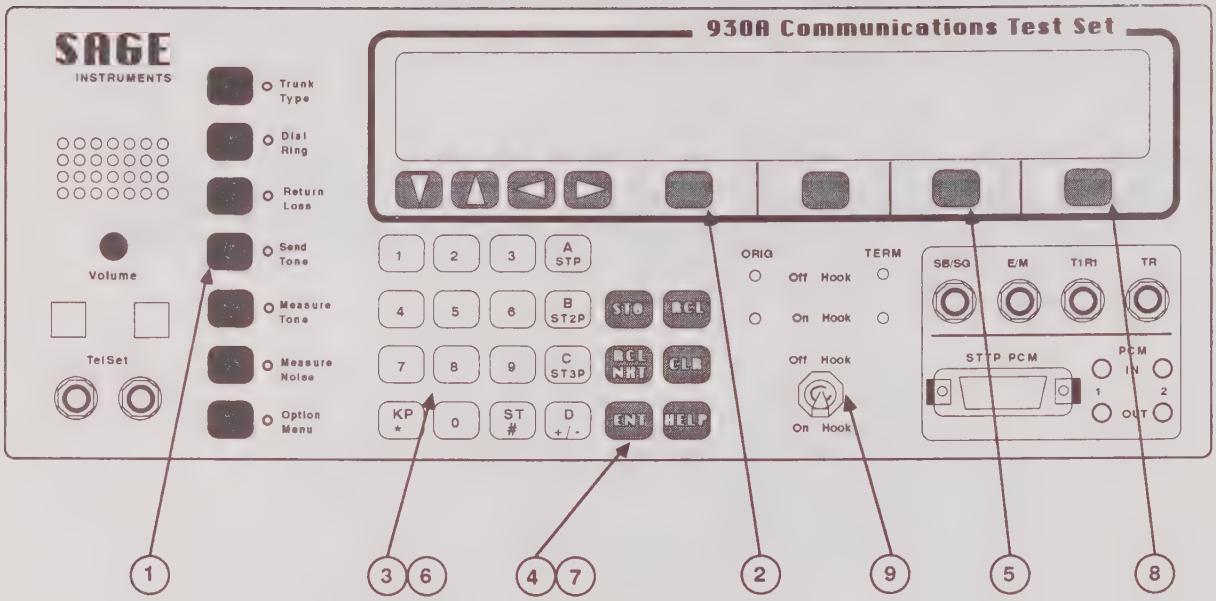
IN TR TERMINATION (2 WIRE CIRCUITS ONLY):

Softkey 2 is inactive.

Softkey 3 is a wheel which enables the user to select the type of termination (AC SHORT, AC OPEN, 600 ohm w/2.16 ufd, or 900 ohm w/ 2.16 ufd).

Softkey 4 is inactive.

NOTE: TR Termination is available only if the 930A is in a 2-wire mode.



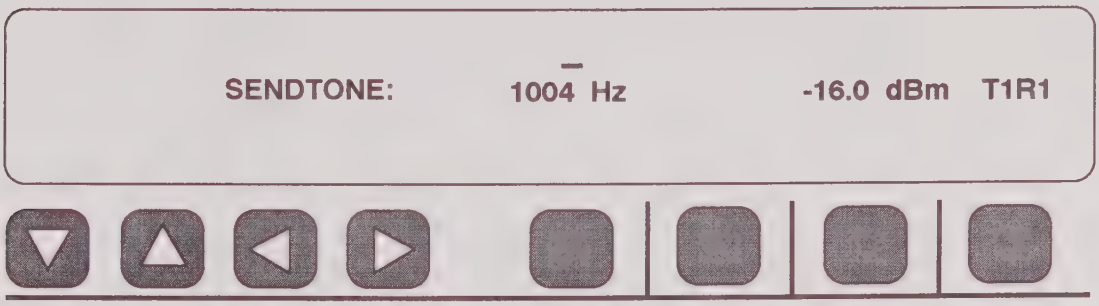
To Send a Tone:

1. Press the SEND TONE function key.
2. Press Softkey 1 to allow frequency changes.
3. Enter the desired frequency using the numeric keypad.
4. Press the ENT (Enter) key to enter the frequency.
5. Press Softkey 3 to allow level changes.
6. Enter desired level using numeric keypad.
7. Press the ENT key.
8. Press Softkey 4 to turn on the generator or to turn it off and supply quiet termination.
9. Ensure that Switchhook is OFF HOOK to send tones.

SENDING A TONE
FIGURE 3-12

3-9 SEND TONE FUNCTION KEY

Figure 3-12 shows the key locations and gives step-by step instructions for sending a tone at a specified level. Pressing the SEND TONE key will display the current values of the level and frequency being sent. The frequency is adjustable over the 20 Hz to 5 KHz range on Analog trunks and 20 Hz to 3904 Hz on PCM trunks (Optional). The level is adjustable from -50.0 dBm to +12.0 dBm on Analog trunks and from -40.0 dBm to +3.0 dBm on PCM. A typical Send Tone display is provided below for example purposes:



The functions of the front panel keys in the SEND TONE mode are:

Softkey 1 moves the cursor to the least significant digit of the frequency display. Numeric input will be treated as a frequency selection.

Softkey 2 is inactive.

Softkey 3 moves the cursor to the least significant digit of the level display. Numeric input will be treated as a level selection.

Softkey 4 toggles between Tone ON and Tone OFF. If the tone is ON, "TR", "T1R1", "PCM1", or "PCM2" will be displayed depending upon the trunk type and direction. If OFF is selected then no tone is sent and the 930A supplies quiet termination.

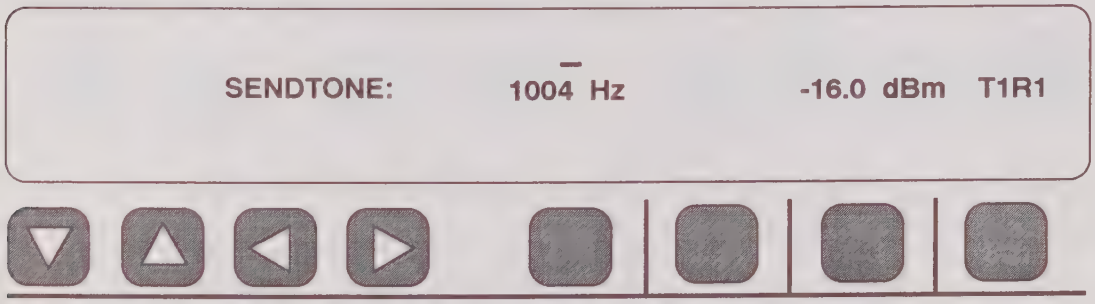
Whenever the Model 930A is operating in a mode other than SEND TONE and a tone is being sent, the LED beside the SEND TONE function key will flash to alert the operator to the fact that tone is being sent. If no tone is desired the operator should return to the SEND TONE function and use Softkey 4 to

place the unit in Quiet Termination by selecting "OFF". The tone selected in SEND TONE is not sent in the DIAL/RING or RETURN LOSS functions.

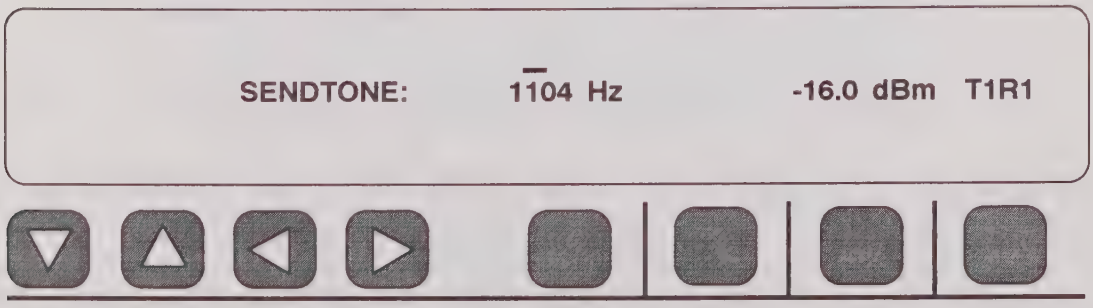
The Left and Right arrow keys position the cursor within a selected field, either frequency or level, from least significant to most significant digit.

The Up and Down arrow keys increment or decrement the frequency or level depending upon the position of the cursor. The step size depends upon the position of the cursor within the field and may be either 1, 10, 100, or 1000 Hz in frequency or 0.1, 1, or 10 dB in level.

An example of the SEND TONE mode should help to clarify this function.



Press Softkey 1 under the frequency display to move the cursor over the least significant digit of the frequency. Press the left arrow key twice to move the cursor over the hundred Hertz column of the frequency display. Pressing the Up or Down arrow key now varies the frequency of the tone in 100 Hz steps. Press the Up key once and the display changes to:

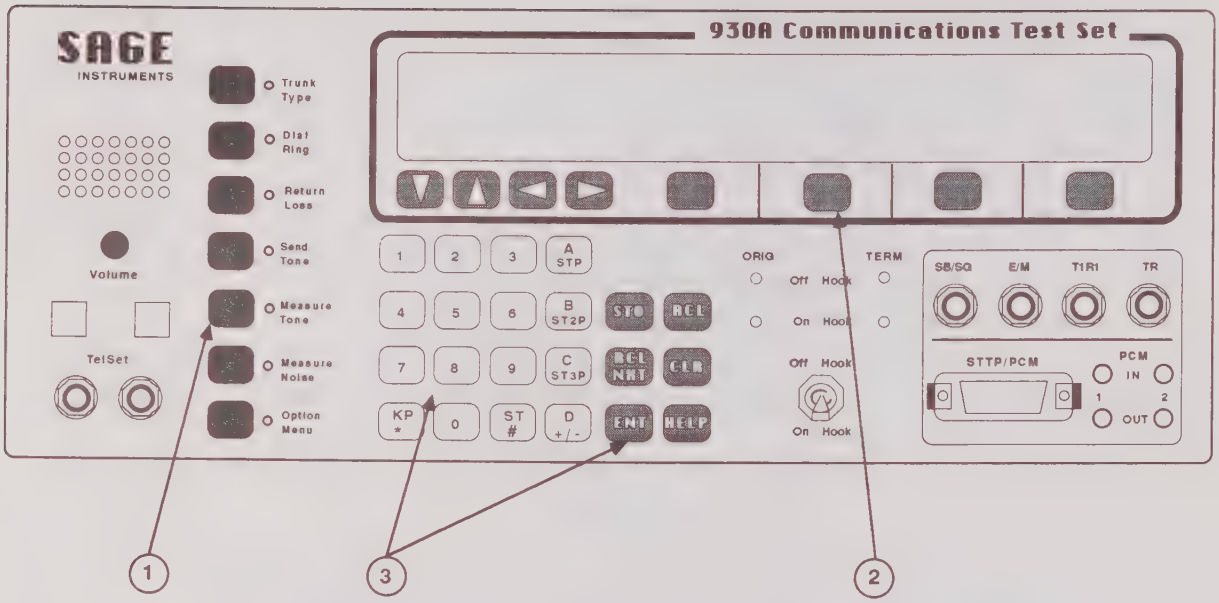


Holding down the Up and Down arrow keys will cause the Model 930A to sweep through the frequency or level steps. By selecting the appropriate frequency step size, for example, the operator can generate a manual frequency sweep. In particular, the operator may desire to sweep from 204 Hz to 3904 Hz in 100 Hz steps. Simply select frequency by pressing Softkey 1. Enter 204 Hz using the numeric keypad. Move the cursor over the hundreds digit using the left arrow key. Check to be sure that the correct level is being sent. Press the Up arrow key to increment the tone from 204 Hz to 304 Hz. Hold the key down to auto-increment the frequency up to 3904 Hz.

The Model 930A is capable of automatically sweeping tones over user defineable ranges. This standard feature is described in Section 3-12.4 FREQUENCY SWEEP since it is accessed under the Option Menu Function key.

NOTE:

The Model 930A does not go above 3904 Hz in the PCM mode.



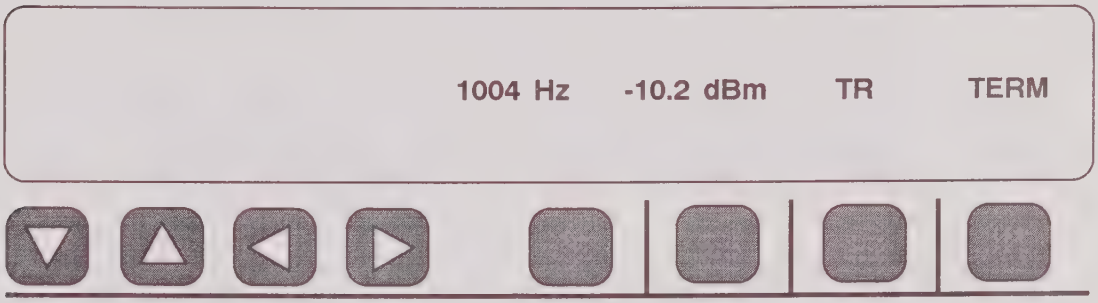
To Measure a Received Tone:

1. Press the MEASURE TONE function key.
2. Press Softkey 2 to enter the TLP correction factor, measure in dBm, or set a 0 dB reference point for comparisons.
3. Use the numeric keypad to enter the TLP correction factor if required.

MEASURING A TONE
FIGURE 3-13

3-10 MEASURE TONE FUNCTION KEY

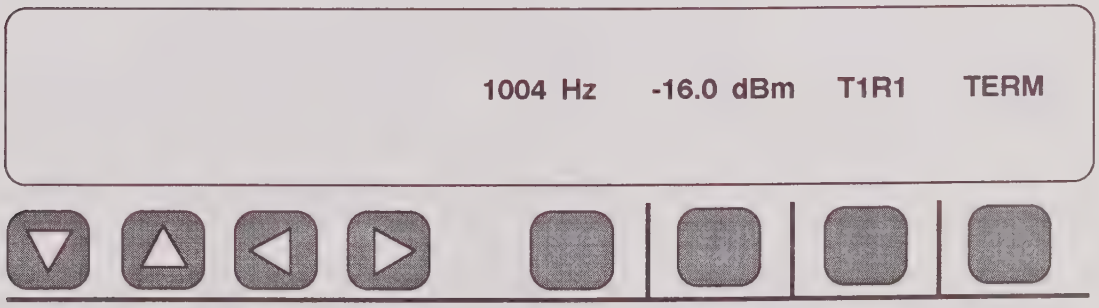
The Model 930A provides the operator with the means to measure and display the level and frequency of received tones. Figure 3-13 shows the locations of the keys and provides step-by-step instructions. Press the MEASURE TONE function key and the 930A will display the measured level and frequency of any tone present.



The functions of the front panel keys in the MEASURE TONE mode are as follows:

Softkey 1 is inactive.

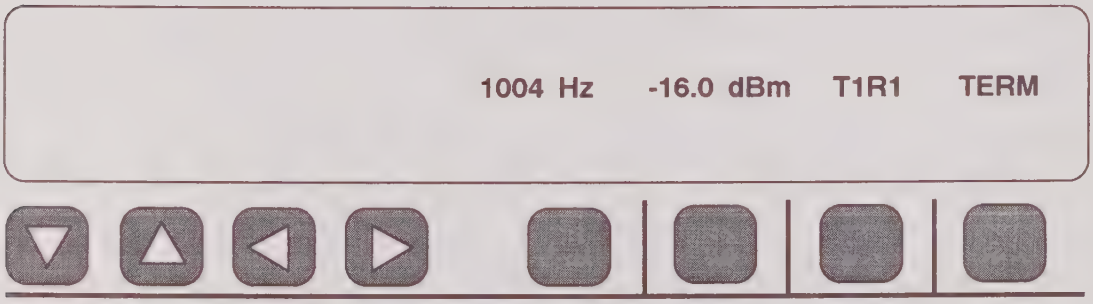
Softkey 3 is inactive. The display above it shows the input from which the measurements are being taken. That is TR, T1R1, and optionally PCM1, or PCM2.



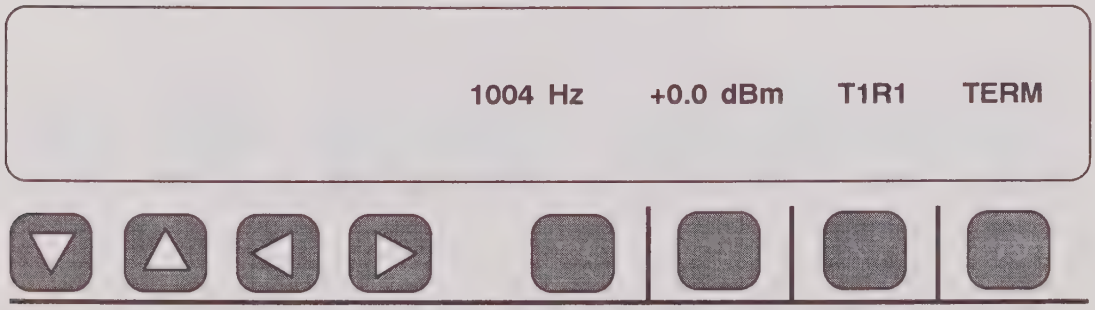
Softkey 4 is inactive. The operating mode, either BRIDGE or TERMINATE, is displayed above this key. These states can only be changed in TRUNK TYPE mode.

Softkey 2 is a wheel which enables the user to select the zero dB level relative to the current measurement. Initially the 930A displays the measurement in dBm. Press Softkey 2 once to lock in the current measured value as the 0 dB reference point. Pressing Softkey 2 again enables the user to input a relative zero numerically (Numeric entry from the front panel keypad must be terminated by pressing ENTER or any Softkey). Another press of Softkey 2 will return the 930A to dBm measurement. For convenience, the 930A displays measurements in dBm (Absolute relative to 1 milliwatt), dB (relative to a measured zero), or dBm0 (relative to a specified zero or transmission level point).

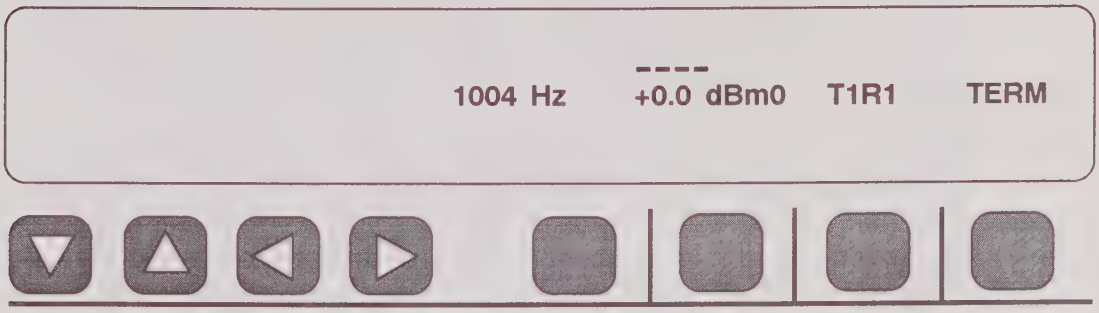
The following illustrations show a typical example of a Measure Tone display as Softkey 2 is pressed starting with the initial dBm measurement:



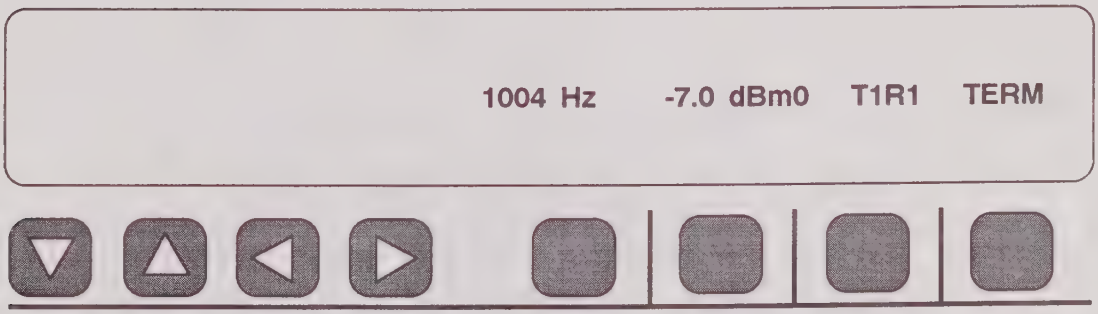
Press Softkey 2 once to lock in the current measured value as the 0 dB reference and the display shows:



Press Softkey 2 again and a flashing cursor appears over the reference level indicating that the 930A expects a numerical value to be input for the TLP as shown:

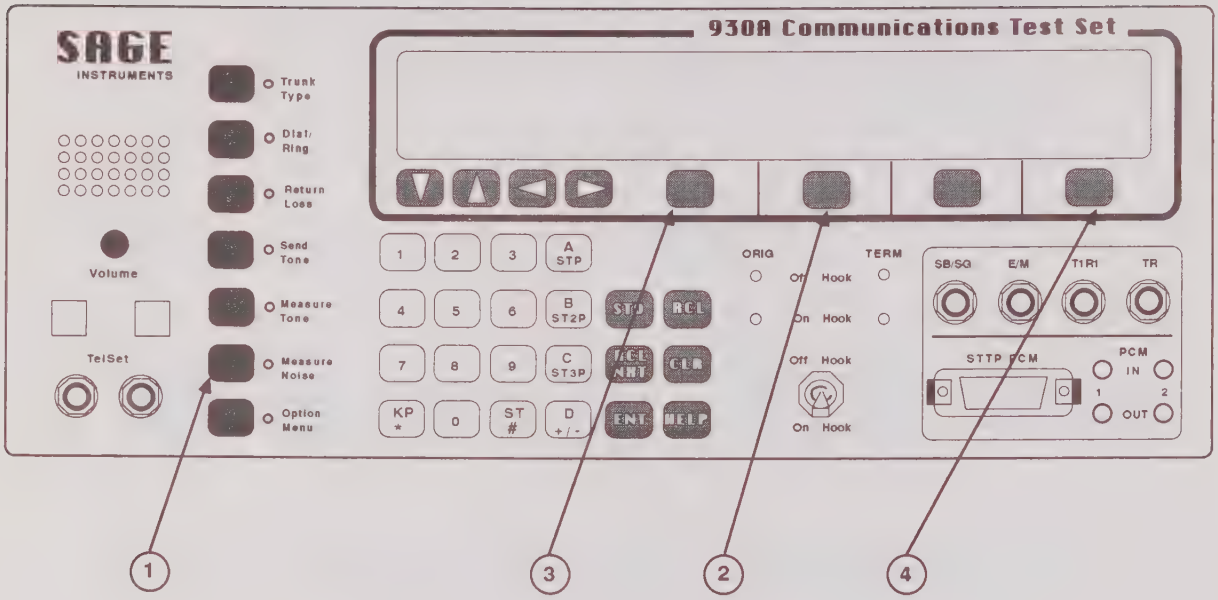


For example, suppose the TLP at the measurement point is -9.0 dB. Then simply pressing the +/- key, entering 9 and 0, and pressing the ENTER key will cause the 930A to immediately change the measurement displayed to:



This display shows that a -16.0 dBm signal, referenced to a -9.0 dB TLP, is a -7.0 dBm0 level.

Accurate measurements can only be made if the proper impedance has been selected in TRUNK TYPE mode. In Loop and Ground Start modes, the position of the Hook Switch can affect the AC Termination and therefore the measured level.



To Measure Noise or Signal to Noise:

1. Press the MEASURE NOISE function key.
2. Press Softkey 2 to select weighting filter (3 KHz FLAT, C-MESSAGE or C-NOTCH) or Signal to Noise (S/N).
3. Press Softkey 1 to select relative dB (dBrn or dBrnC), 0 dB reference point, or to enter TLP correction factor.
4. Press Softkey 4 to select Balanced or Noise to Ground measurements.

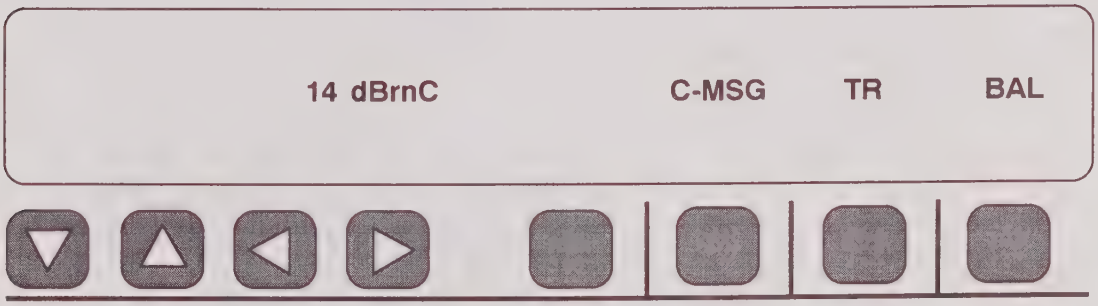
NOISE MEASUREMENT
FIGURE 3-14

3-11 MEASURE NOISE FUNCTION KEY

Noise measurement using the Model 930A is easily accomplished by pressing the MEASURE NOISE function key. This causes the 930A to display the current measurements, weighting filter types, source, and balance. Figure 3-14 shows the location of the keys and provides step-by-step instructions for noise measurements.

The Model 930A measures C-Message, C-Notched and 3 KHz Flat weighted noise as well as Signal to Noise Ratio on 2 and 4 Wire metallic circuits or 64 Kbps DS-0 channels (optional).

A typical display might appear as:



The functions of the front panel keys are as follows:

Softkey 1 is a wheel which enables the user to select the measurement units. That is, either dBrn (Absolute), dB (relative to the level being measured when dB was selected), or dBrn0 (relative to a level which is input numerically). Refer back to Section 3-10 and the explanation of MEASURE TONE's Softkey 2 for more details.

Softkey 2 is a wheel which allows the user to select the type of weighting filter desired for a particular measurement. The choices are: C-MESSAGE, C-NOTCH, 3KHz FLAT and S/N.

Softkey 3 is inactive. The input signal source is displayed above it.

Softkey 4 is a wheel which enables the user to select either balanced or Noise-to-Ground measurements on analog trunks. Optionally, on PCM trunks this window is labeled "CHANNEL" to indicate that the noise being measured is the noise on one channel and not the entire 24 channels. Softkey 4 is inactive on PCM trunks and also during S/N measurements which are only done as balanced measurements.

It is possible to set the relative zero, for measurements in dB, using one weighting filter and then change to another filter. The display will then show the measurement in one filter relative to the other. This feature is particularly useful for measuring notch depth. The following example will serve to illustrate the procedure.

EXAMPLE: Select the C-MESSAGE filter. Press Softkey 1 to set the relative zero equal to the currently displayed measurement. The measurement should now read 0 dB. Press Softkey 2 and select C-NOTCH. The display will show the notch depth for the tone being measured. For analog trunks the displayed value will be greater than 40 dB. For PCM trunks the number will normally be 39 or 40 dB. Notch depth is limited by PCM coding to approximately 39 dB when using robbed bit signaling and 42 dB with CCIS signaling.

Signal to Noise ratio measurements are closely related to notched noise measurements. Signal to Noise ratio measures the power in a 1010 Hz holding tone compared to the C- Message noise power on the channel under test. To perform this measurement, most test sets use the 1010 Hz C-Notch weighted filter so that the tone and noise can be measured simultaneously while keeping the relative error acceptably small.

The following example explains how to measure S/N ratio with the Model 930A.

EXAMPLE: SIGNAL TO NOISE RATIO (S/N)

In this example, it is desired to check the S/N ratio on a 2-Wire 900 ohm circuit to ascertain whether the circuit can meet the requirements of a 9600 baud, half duplex Modem which needs a minimum S/N ratio of 28 dB according to its specifications. **REMEMBER:** The 930A must be receiving a 1010 Hz tone from the far end or it must be sending 1010 Hz in a loopback mode to measure S/N ratio.

To begin, set up the 930A to the appropriate Trunk Type following the procedure in Section 3-6. In this example the Trunk Type is a 2-Wire, 900 ohm loop start trunk and the correct 930A display is obtained by the following steps:

Press the **Trunk Type** function key.

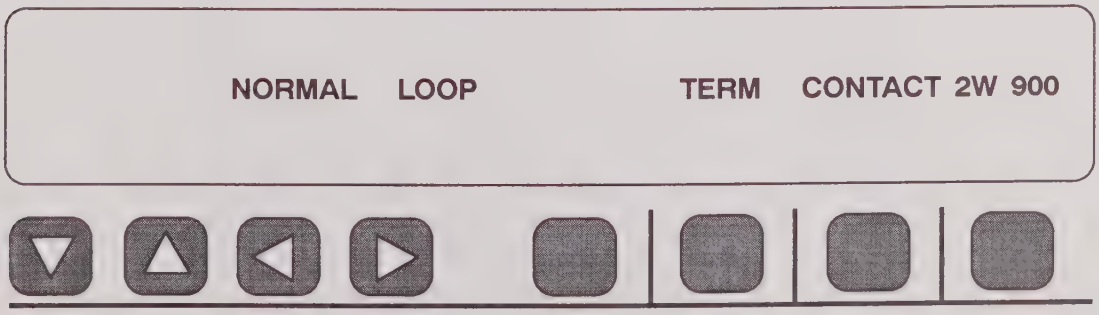
Use Softkey 1 or the UP/DOWN arrow keys to page through the available trunk types until Normal Loop is displayed.

Press Softkey 2 to terminate the trunk.

Press Softkey 3 to select CONTACT (to simulate the station end of the trunk) or BATTERY (to simulate the Central Office) as appropriate.

Press Softkey 4 until 2-Wire, 900 ohm operation is displayed.

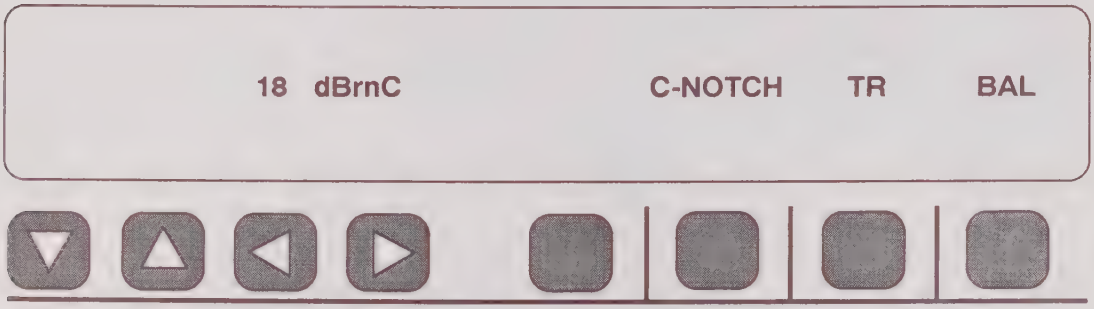
The 930A display is shown below (simulating the station end of the trunk):



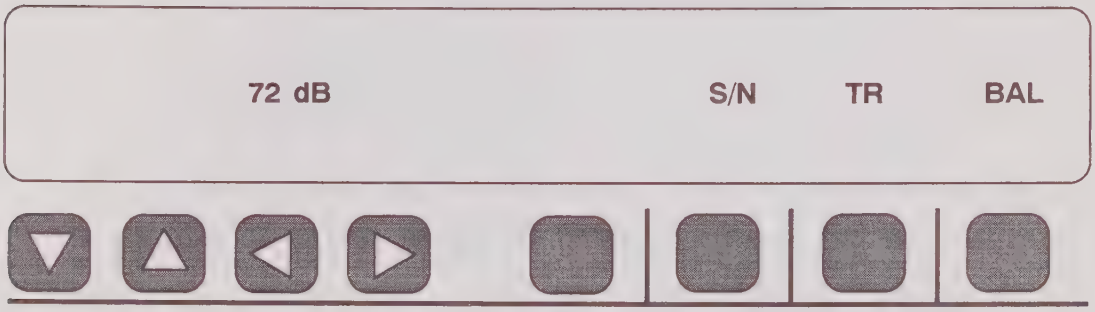
Once the correct trunk type has been chosen, the next step is to select the MEASURE NOISE function. Remember that this procedure is valid for any trunk type and Loop is being used only for example purposes.

Press the Measure Noise Measure Noise key.

Unless the 930A had previously been set to the S/N measurement it will be necessary to select it. Assume that the 930A display is similar to the one shown below after the Measure Noise key is pressed.



Press Softkey 2 until the S/N ratio display appears. An example display is shown below:



REMINDER: The S/N ratio measurement requires that a 1010 Hz tone be present at the measuring end of the circuit. On 2- wire trunks this usually means making an end-to-end measurement with one test set supplying the 1010 Hz from one end and the other test set measuring the S/N at the other end. On a 4-wire trunk the far end can be looped back. In this case the 930A can generate a 1010 Hz tone at the appropriate level and then measure the S/N ratio coming back.

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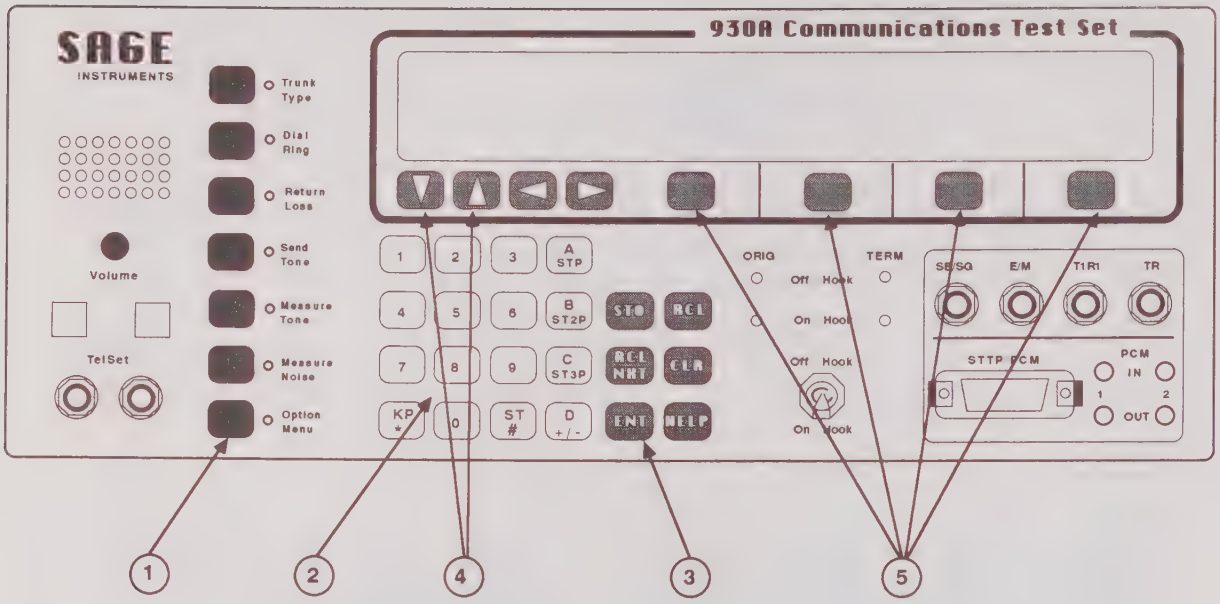


To Select Menu Options:

1. Press the OPTION MENU key.
2. Enter the number of the Menu Option desired (1 to 98).
3. Press the ENT(Enter) key to initiate the menu option choice.
4. Alternatively, after step 1, the operator may use the UP/DOWN arrow keys to scroll through the menu option choices.
5. In this case, the user must press any softkey to enter inside the desired menu option once it has been selected.

MENU OPTION SELECTION
FIGURE 3-15

3-12 OPTION MENU FUNCTION KEY

The OPTION MENU function key permits the capabilities of the 930A to be expanded without making the front panel too complex. The front panel of the 930A has been designed so that the most frequently used test functions have their own individual keys. The less frequently used functions, the functions with more complex set-ups, and those functions which are acquired through the purchase of options (ROTL/Responder testing, Impulse Noise, P/AR, etc.) have been placed under the OPTION MENU key. There are 98 possible menu options for the Model 930A which means that there is plenty of room for growth without rapid obsolescence.

Figure 3-15 shows the key locations and gives step-by-step instructions for their use.

NOTE:

The option numbers for the OPTION MENU functions should not be confused with the order numbers of purchased options.

Pressing the OPTION MENU key causes the 930A to display the most recently selected menu option number and function name. The Up and Down arrow keys allow the user to scroll through the menu option selections. Each menu option displays the number and name of the function if one has been installed. The arrow keys will auto-repeat if held down. Pressing any Softkey will select the menu option currently displayed. Entering a number from the numeric keypad and pressing ENTER will cause the 930A to go directly to that menu option number and enter it. To exit from a menu option at any time, press the OPTION MENU key or any other function key. Some menu options also have a field labeled EXIT and pressing the associated Softkey will cause the 930A to exit that option.

NOTE: To store the parameters which have been set up in a menu option it is necessary to exit from that option. To do this, press the OPTION MENU key, then press the STORE key and enter a storage location number. The only exception to this is Option 1: Modify Dial/Ring. This is explained in greater detail in Section 3-12.1.

There are 98 possible menu options for the Model 930A as previously mentioned. In the majority of cases not all menu options will be installed. Some will be reserved for future expansion. These menu options will be labeled "Not Installed" and selecting them will have no effect. There are ten menu options included as standard in all Model 930A's. These are:

OPTION 01: MODIFY DIAL/RING
OPTION 02: SEND DIGIT SEQUENCES
OPTION 06: DC VOLTMETER
OPTION 07: SUPERVISION THRESHOLDS
OPTION 08: SUPERVISION MONITOR
OPTION 09: WINK TIMING
OPTION 10: FREQUENCY SWEEP
OPTION 15: BEEP ON ERROR
OPTION 30: ADJUST TLP
OPTION 31: SEND HOOK FLASH
OPTION 32: DIAL-UP TESTLINE

The functions of these menu options and their operation is described in Sections 3-12.1 to 3-12.11. This manual also covers the function and operation of the purchased options (Refer to Section 4) as they relate to the OPTION MENU. These purchased options and their associated menu option numbers are:

Purchased Option 930A-01 (DP, DTMF and MF Receiver/Analyzer) provides the operator with Menu Options 4 and 12 which are the Digit Receiver and Wink Margining. These menu options are described in Section 4-2.

Purchased Option 930A-08 or -09 (Single or Dual Direction PCM Channel Access) uses menu option 20 to provide the operator with a display of the A and B signaling bits status on all 24 PCM channels. Menu option 21 allows the operator to toggle the A and B bits independently and display their status on any selected channel. These menu options are discussed in greater detail in Section 4-6.

Purchased Option 930A-10C (Remote Control) uses menu option 3 to provide the operator with the choice of Printer, Terminal, Computer, or Master/Slave modes of operation. Real Time Clock is also a part of Option 930A-10C and is displayed under Menu Option Number 14. Remote control operation of the Model 930A is described in Section V.

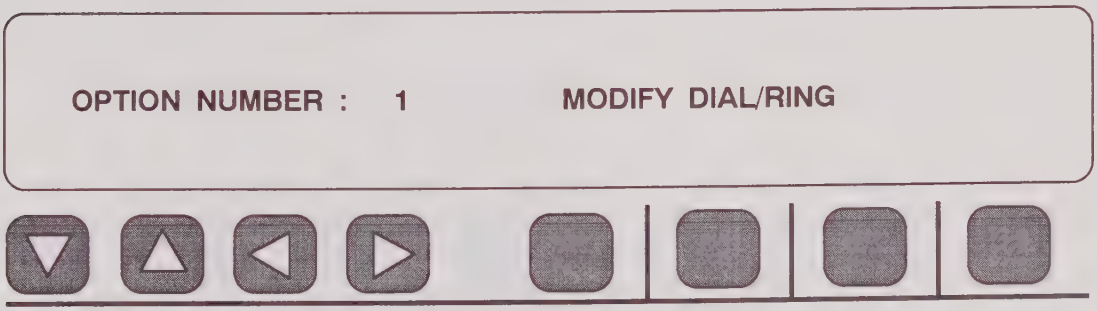
The optional trunk types such as PCM, SF, and STTP/LTTP are not accessed through the menu option but through the TRUNK TYPE function key. These optional trunk types are discussed in Section IV.

3-12.1 MENU OPTION NUMBER: 1 MODIFY DIAL/RING

Menu Option 1, MODIFY DIAL/RING, is used to modify the parameters of outpulsed digits or the Ring Generator (Option 930A-13). This menu option is standard on all Model 930A's and is particularly useful for tolerance testing. That is, testing the ability of far end equipment to recover distorted or non-standard digit transmissions. To begin testing, perform the following steps:

Press the OPTION MENU Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 1. The Model 930A display will appear as follows:



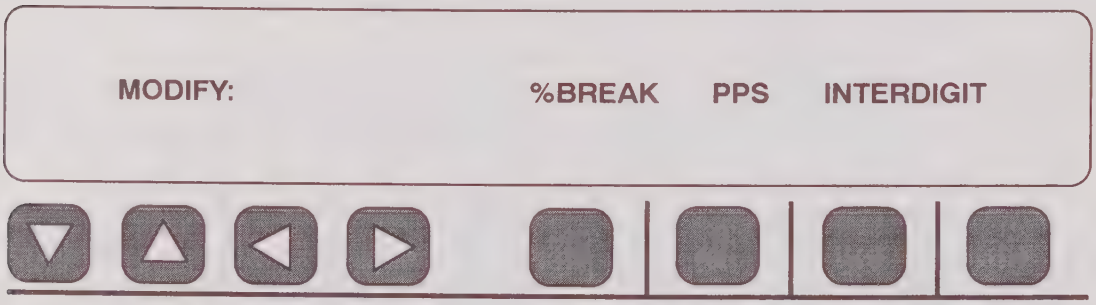
Press any Softkey to enter the function.

NOTE: Entering a numeric 1 and pressing the ENTER key will cause the 930A to go directly to Menu Option 1 and enter it.

This Section will consider only the modification of outpulsed digits which is a standard feature. The modification of the Ring Generator parameters is covered in Section 4-9. The Ring Generator is purchased option 930A-13.

Once the operator has entered the function there will be one of two possible displays shown. If the operator has previously selected the MF or DTMF outpulsing mode (refer to Section 3-7) then the display will appear as:

If the operator has previously selected Dial Pulse (DP), then the display will be:



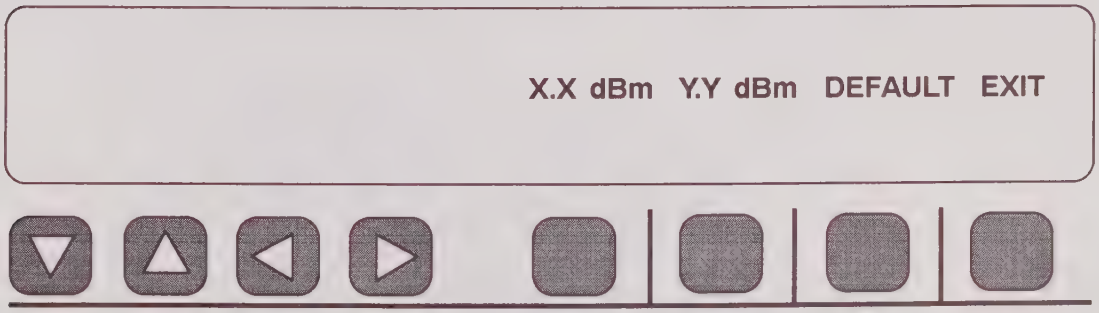
The following sub-sections outline the procedures for modifying the parameters in any of the modes.

3-12.1.1 MF OR DTMF MODE

In the MF or DTMF mode the MODIFY SEND DIGITS display will appear as:

Use Softkey 1 to inspect or modify the tone levels.
Use Softkey 2 to inspect or modify the tone frequencies.
Use Softkey 3 to inspect or modify the timing.

Press any Function key to exit from this mode and the modifications will be "remembered" by the 930A. Pressing Softkey 1 (LEVEL) will bring up the following display:



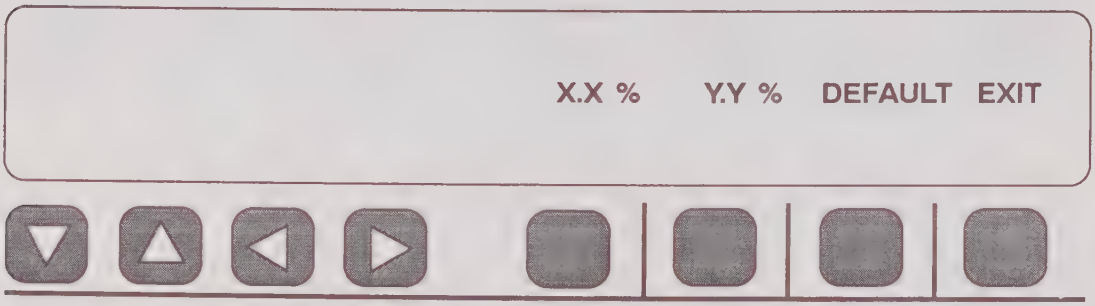
where X.X and Y.Y are the levels at which the low tone and high tone, respectively, are being sent.

Use Softkeys 1 and 2 to select which tone level is to be modified and enter the desired level using the Numeric Keypad.

Use Softkey 3 to select the AT&T Standard levels.

Use Softkey 4 to return to the "MODIFY" display.

Pressing Softkey 2 (FREQ) will bring up the following display:

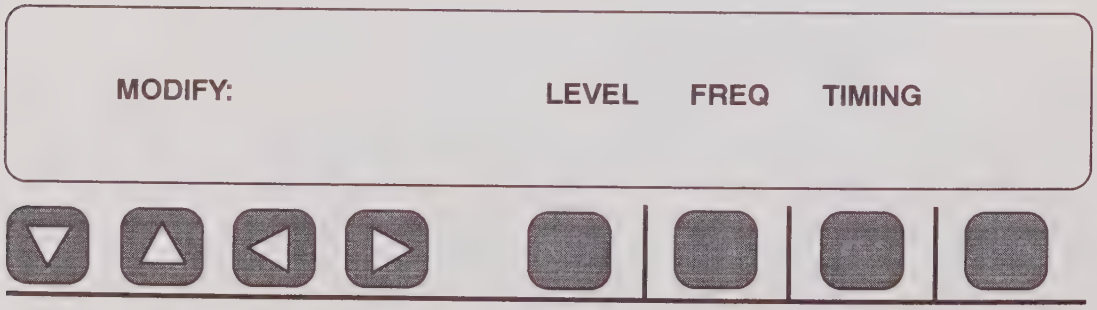


where X.X and Y.Y are the percentages above or below (+/-) the AT&T standard frequencies for each of the dual tones.

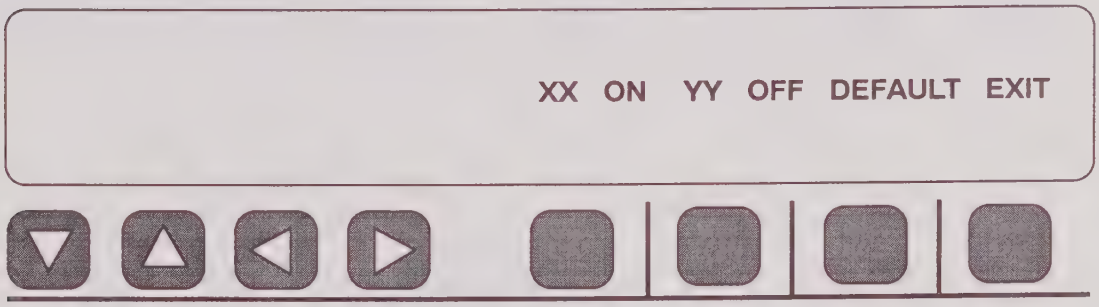
Use Softkeys 1 and 2 to select which tone frequency is to be modified and then enter the percentage (either + or -) numerically from the keypad and press ENTER. Typical values might be +/- 2% to +/- 5%.

Use Softkey 3 to select the AT&T standard values without deviation.

Use Softkey 4 to return to the "MODIFY" display.



Pressing Softkey 3 (TIMING) brings up the following display:



where XX is the number of milliseconds the tones are ON and YY is the interdigit time (time between tones) in milliseconds.

Use Softkeys 1 and 2 to select which parameter is modified and then enter the desired amount numerically.

Use Softkey 3 to enter the AT&T standard values. These will vary depending upon whether MF or DTMF has been selected.

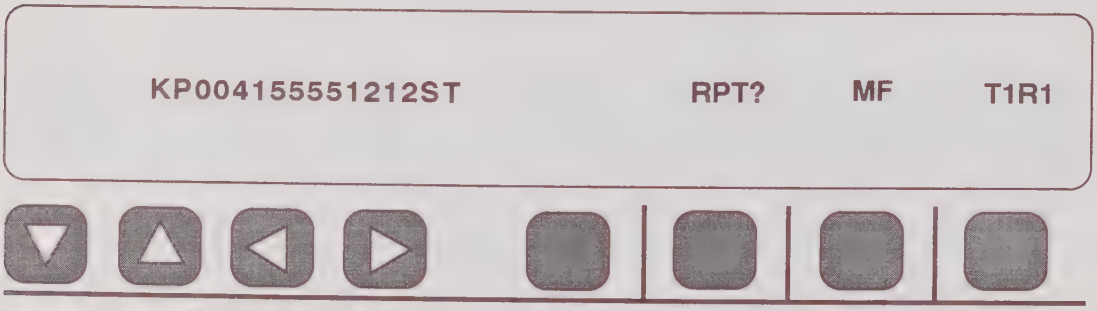
Use Softkey 4 to return to the "MODIFY" display.

Pressing any Function key will exit to that function, causing the modifications to be retained in non-volatile memory. In the DIAL/RING Function any sequence of digits which is outpulsed will be sent with the modifications set in the MODIFY DIAL/RING menu. It is often convenient during testing to store the same outpulsing sequence with and without modifications. To illustrate this procedure let us take the simple case of an MF sequence and show how to store it for future recall with and without modification.

EXAMPLE: STORING A MODIFIED / UNMODIFIED SEQUENCE

The storing of an unmodified sequence followed by a modified sequence has use when the operator is routining a switch or checking performance limits. The idea is to first send a sequence that is "in spec." to verify proper operation and then send a sequence with modified parameters to "stress" the system to it's limits and verify that it is still capable of operating.

For this example, suppose that the desired sequence is the MF string, KP004085551212ST. This is entered in by the operator using the DIAL/RING Function and the numeric keypad as outlined in Section 3-7. The 930A display, after the number is entered, will look like:



Note that this procedure will work for any trunk type.

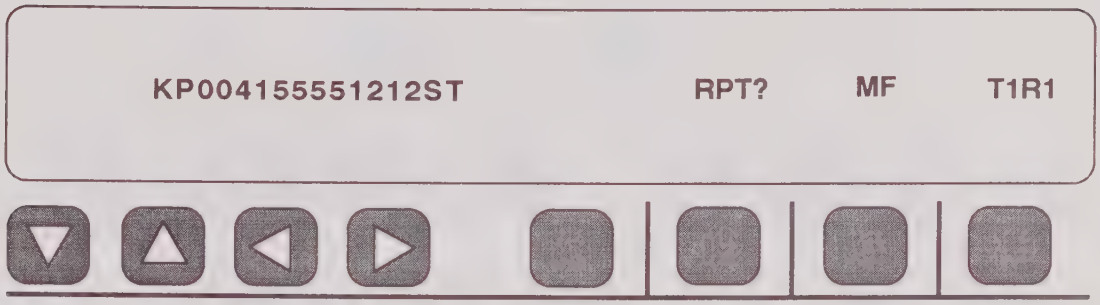
The procedure for entering and storing an unmodified digit sequence is:

1. Use Softkey 3 to select the desired outpulsing type (MF, DTMF or DP).

2. If the outpulsing parameters have been modified, the outpulsing type will be preceded by a ">" character (i.e., ">MF").

3. To clear any modifications, press Softkey 3 three times. This re-selects the current outpulsing type. When an outpulsing type is selected using Softkey 3, the AT&T default parameters are selected.

4. Enter the desired digit sequence using the numeric keypad. For this example, an MF sequence is used as shown below:



To store this unmodified sequence in register location 30, for example, perform the following steps:

Press the STORE STO key, then 3 then 0

and then press the ENTER ENT key.

The unmodified sequence has now been stored in register location 30 and the Model 930A has automatically incremented to register location 31 which will save the operator from having to enter "31" in the upcoming series of steps.

The next step is to go to Menu Option 1 to modify some of the parameters. The steps are:

Press the OPTION MENU O Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 1, if it is not already displayed.

Press any Softkey to enter the option and the display will be:

Once within Menu Option 1 the operator may, for example, desire to modify the frequency of the MF tones.

Suppose it is desired to modify the frequency of the tones 2% up and 3% down. To accomplish this modification perform the following steps:

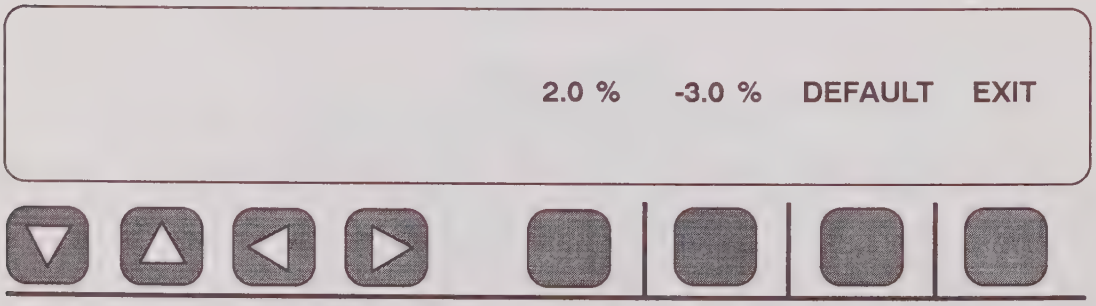
Press Softkey 1 and enter 2.0% numerically to increase the tone frequencies 2.0%. That is,

press [2] then [0] and then [ENT]

Then, press Softkey 2 and enter 3.0% and press the +/- key before pressing ENTER to enter the -3.0% value. That is, press

[3] then [0] then [D +/-] and then [ENT]

The 930A display will now look like:



Press the DIAL/RING Dial/ Ring function key.

Now press STO and then ENT

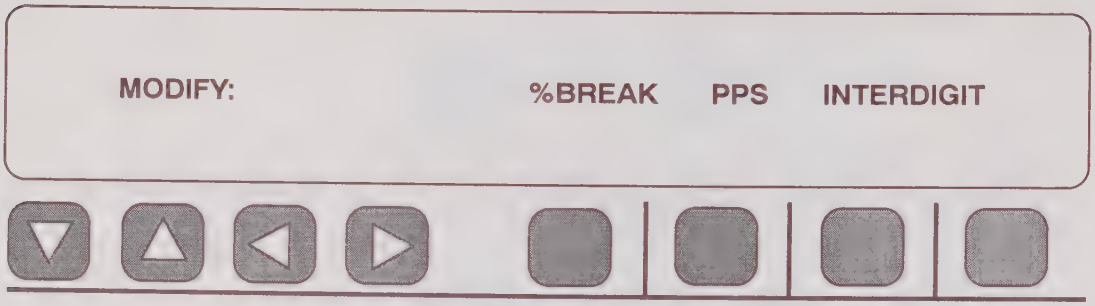
The modified sequence has now been stored in location 31 since the 930A automatically incremented to register 31 after the last storage.

The operator can now Recall "program" 30 to outpulse the normal MF sequence and then Recall 31 to outpulse the modified sequence. Of course, this procedure can be extended to as many modifications as the operator may desire and can also include sending modifications of multiple records.

Simply repeat the steps used above to modify the tone frequency for modifying and storing level changes or timing changes. Storing these changes in sequential register locations is desirable because the operator can step through the tests by simply pressing the RECALL NEXT key.

3-12.1.2 DIAL PULSE (DP) MODE

In the DP or Dial Pulse mode (for Rotary Dial) the display will appear as:

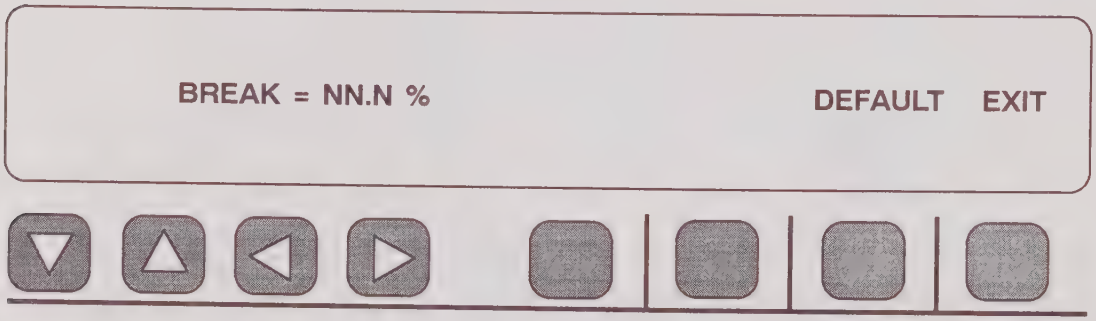


Press Softkey 1 to modify the On-Hook percentage of the pulse.

Press Softkey 2 to modify the number of pulses per second.

Press Softkey 3 to modify the interdigit timing. Press any Function key to exit.

Pressing Softkey 1 (%BREAK) will bring up the following display:



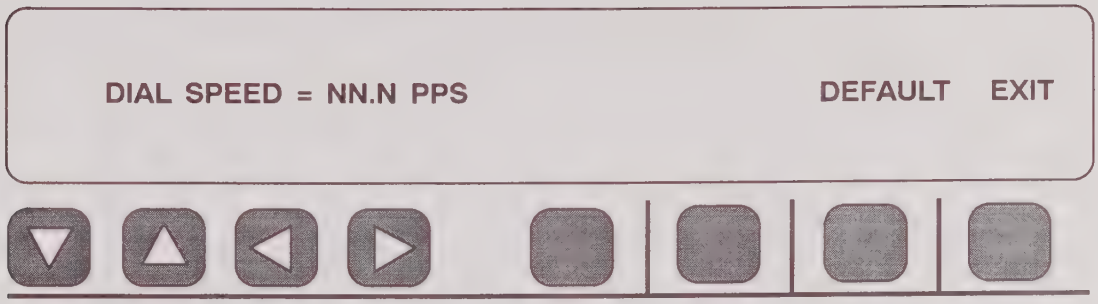
where NN.N is the percentage of each pulse which is On-Hook.

Enter the desired percentage numerically.

Press Softkey 3 to reset the % to the AT&T standard value of 60.0% if desired.

Use Softkey 4 to Exit.

Pressing Softkey 2 (PPS) brings up the following display:



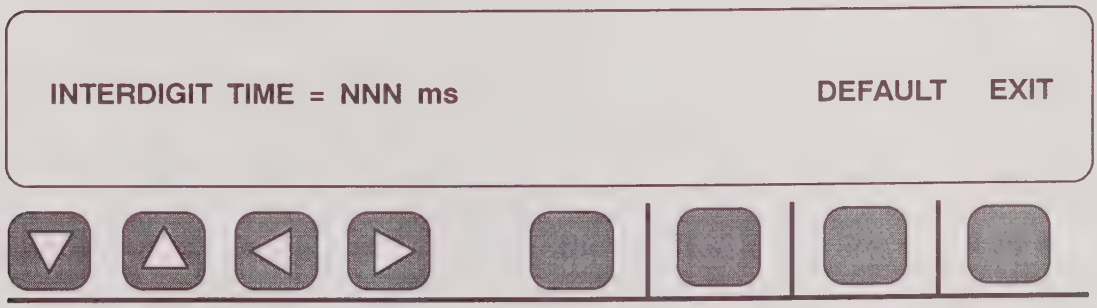
where NN.N is the number of pulses per second.

Enter any desired dial speed numerically.

Press Softkey 3 to reset the dial speed to the AT&T standard of 10 PPS if desired.

Press Softkey 4 to Exit.

Pressing Softkey 3 (INTERDIGIT) brings up the following display:



where NNN is the number of milliseconds between digits.

Enter a new interdigit time numerically as desired.

Press Softkey 3 to return to the AT&T standard value of 700 msec. if desired.

Press Softkey 4 to Exit.

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3-12.2 MENU OPTION NUMBER: 2 SEND DIGIT SEQUENCES

Menu Option 2, SEND DIGIT SEQUENCES, is included on all Model 930A's. This menu option is used for outpulsing very long strings of digits (>18 digits) or for multiple wink sequences such as those found in Equal Access, TSPS, and IDDD applications. The Model 930A can be programmed to pause, to wait for a wink, or to wait for the far-end to answer (go Off-Hook) between digit sequences. When using the SEND DIGIT SEQUENCES function, the operator will find it necessary to **STORE** the different sequences for future recall rather than input them manually each time. The SEND DIGIT SEQUENCES menu option has been designed specifically to use the register locations where the digit strings are stored.

To use SEND DIGIT SEQUENCES then, the desired digit strings should be entered (using **DIAL/RING**) and stored into test memory (using **STO** key) as described in Sections 3-7 and 3-7.1. Store one digit string, or "record", per register location. An example is provided at the end of this section.

NOTE:

Any modifications made in MODIFY DIAL/ RING (Menu Option 1) will also be stored. See the example in Section 3-12.1.1 (page 3-84) for details on storing modified and unmodified digit strings.

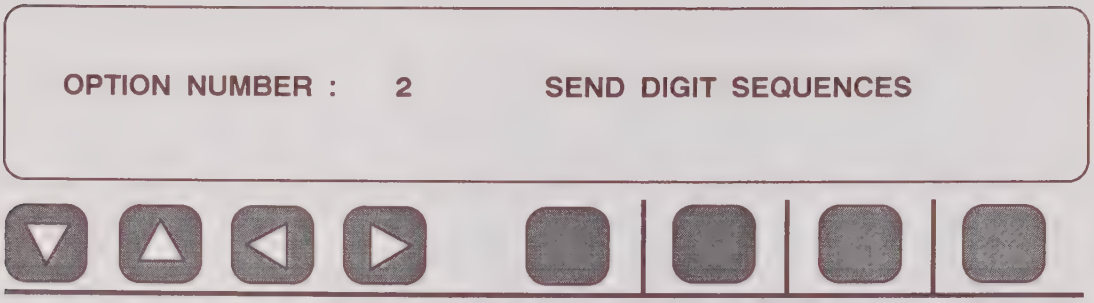
Make sure that the correct Trunk Type has been selected before storing any strings.

The procedure for using the Send Digit Sequences function is outlined below. To begin:

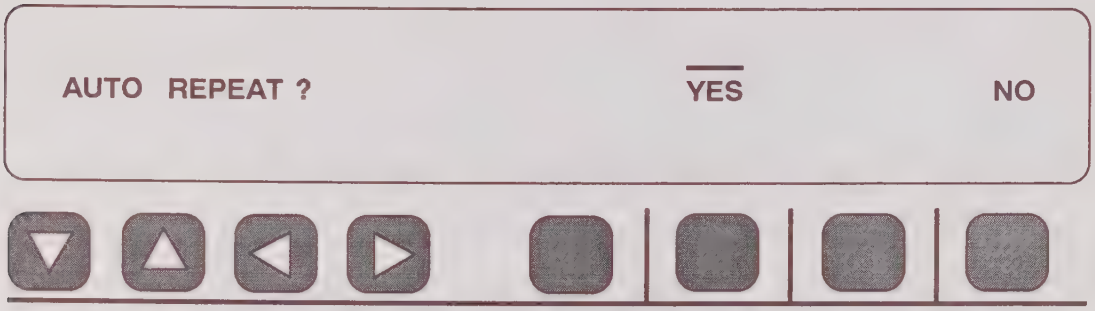
Press the OPTION MENU **Option Menu** function key.

Use the UP/DOWN arrow keys to select Menu Option 2: SEND DIGIT SEQUENCES.

The display will appear as:



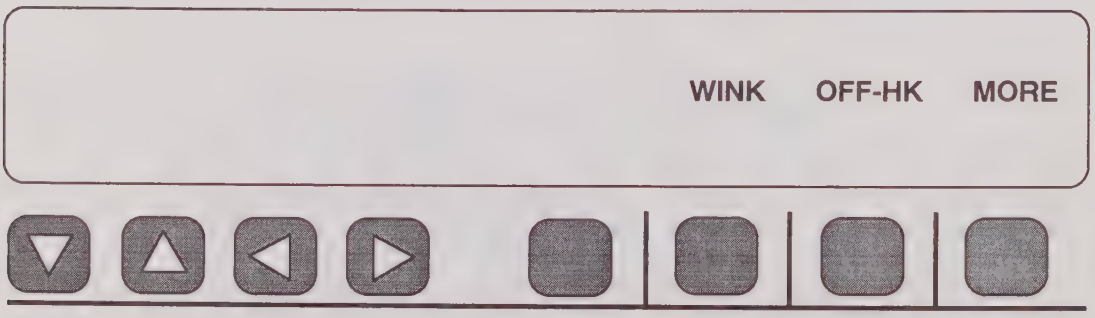
Press any Softkey to enter the menu option and the display will change to:



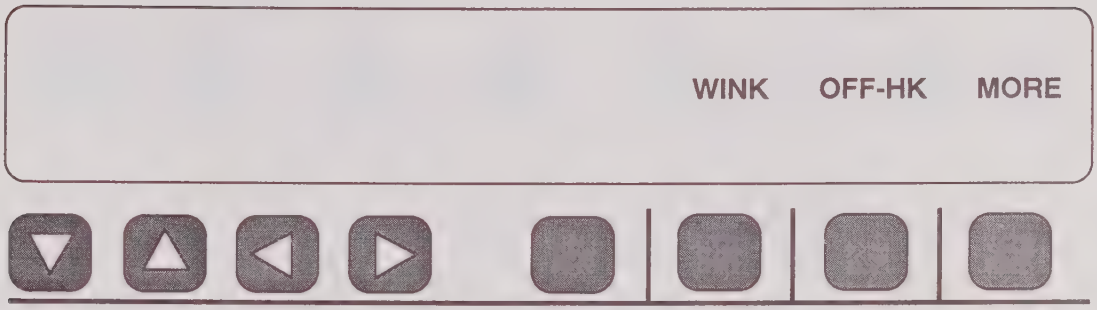
Pressing Softkey 2 will cause the 930A to continuously repeat outpulsing the sequence chosen.

Pressing Softkey 4 will disable the auto repeat function and place the 930A in a manual mode.

Press the Softkey under the desired choice and the 930A screen will become:



If a previous test sequence is present, press the CLEAR CLR key and the display will show:



Numeric inputs are now treated as two digit storage locations (created in **DIAL/RING**) containing the digit sequences. Up to six records may be sent.

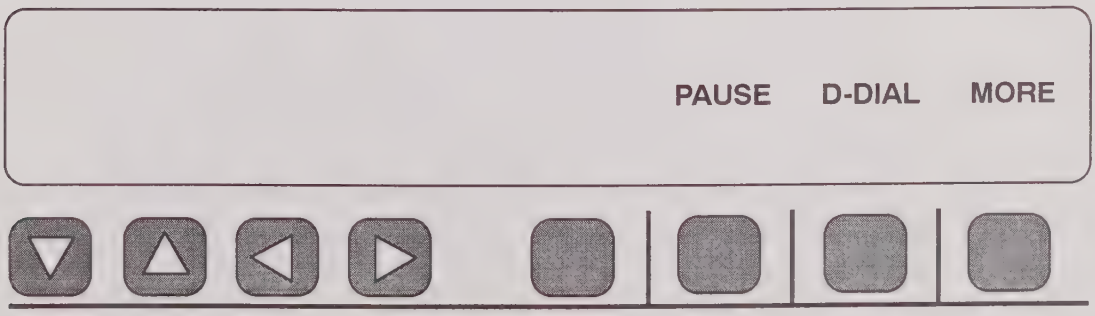
The CLR key clears the input sequences without destroying any stored values.

Softkey 2 programs the 930A to wait for a wink before proceeding.

Softkey 3 programs the 930A to wait until the far end answers (goes Off-Hook) before proceeding.

The LEFT arrow key places a one second pause in the sequence.

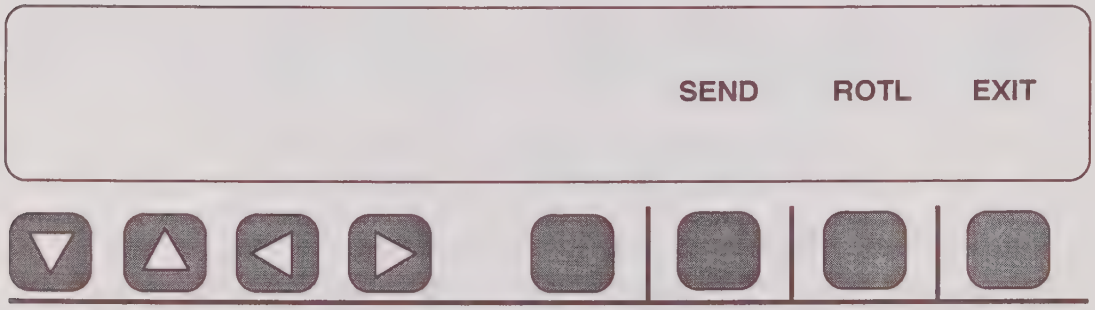
Softkey 4 advances the 930A display to:



Softkey 2 inserts a one second pause into the sequence.

Softkey 3 causes the 930A to wait for a Delay Dial event before proceeding.

Press Softkey 4 to advance the 930A display to:



Press Softkey 2 to outpulse a digit sequence without using the Hook Switch.

Press Softkey 3 to place the 930A in a manual Remote Office Test Line (ROTL) mode at the end of a sequence for Type 105 testing (Requires Opts. 930A-01 and -12) See Section 4-7.2.1 for details on this option.

Press Softkey 4 to exit from this menu option.

Use the front panel hook switch to go OFF HOOK to send the programmed sequence.

NOTE:

Manually going ON HOOK during a sequence will abort the program at the completion of the current record, pause, or wink. If the 930A is expecting a wink and none is supplied within 16 seconds, or the duration of the wink is greater than 600 milliseconds, then the wink will show FAIL on the display and the program will abort. A blinking cursor will appear in the display to indicate which wink has failed if the sequence contains more than one wink.

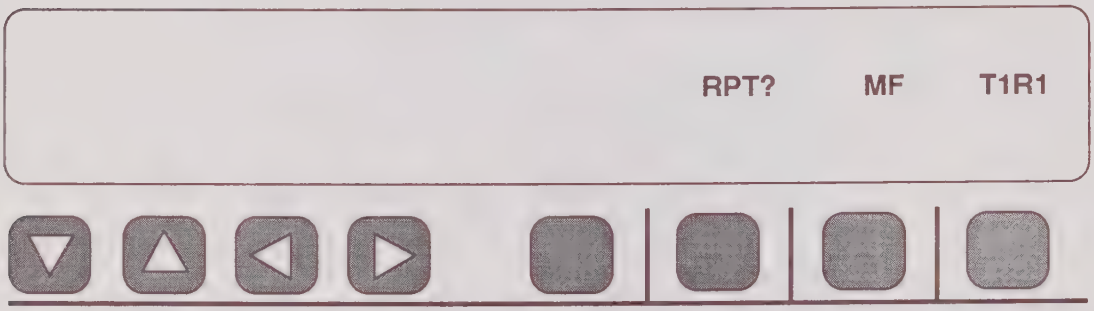
The best way to explain SEND DIGIT SEQUENCES is through examples of typical testing applications. Examples of a Feature Group D Access Tandem simulation and a common Wink Start trunk simulation follow.

3-12.2.1 SENDING AN EQUAL ACCESS SEQUENCE

To simulate placing an Equal Access call from a Bell Operating Company (BOC) switch to an Interconnect Carrier (IC) through an Access Tandem switch the operator would perform the following steps:

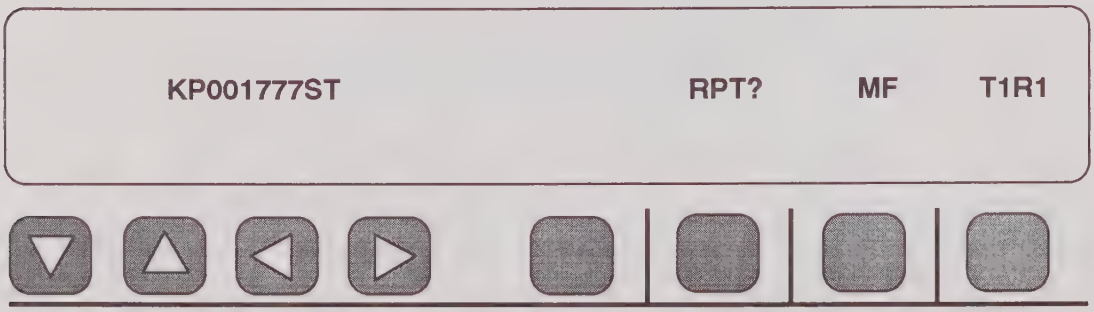
Press the DIAL/RING Dial/ Ring function key.

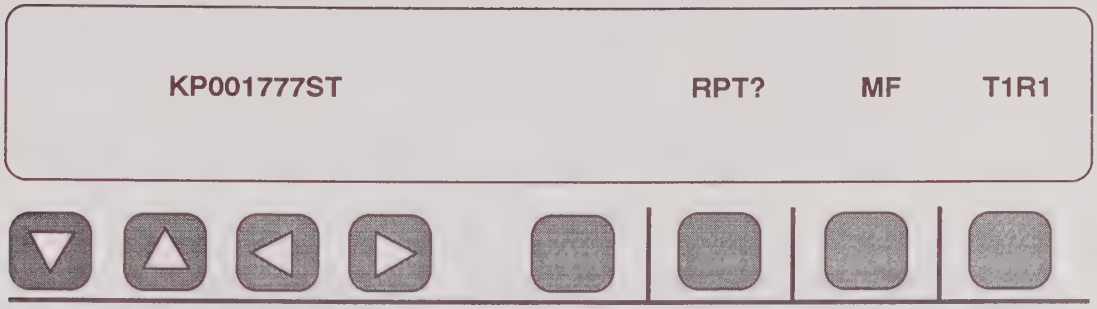
Assume, for this example, that the display appears as:



Use the Numeric Keypad to enter the IC code, which, for example purposes, is assumed to be "KP001777ST", in MF. That is, press KP * , then press 0 twice, then press 1 , then 7 three times, and finally press ST # .

This IC code is for example purposes only and the user should check the local codes in effect for the area. The display will now appear as:





Store this sequence in location 10, for example by pressing the STO 1 0 and ENT keys.

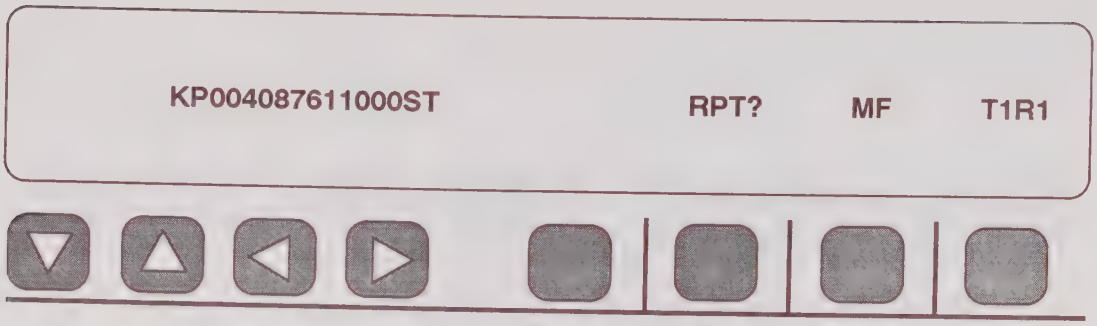
Press the CLEAR CLR key to clear the display and allow entry of the next sequence.

The next sequence in the Equal Access call includes the calling number. For example purposes, let this MF string be "KP004087611000ST". The first two digits are the information digit pair (for inter-LATA restricted lines), and then the 10 digit ANI number (calling number plus area code). The MF delimiters "KP" and "ST" surround the number.

This string is entered in by the following series of keystrokes:

Press KP * , then press 0 twice, then press 4 0 8 7 6 1 1 0 0 0 and finally, press ST #.

The 930A display should now look like:



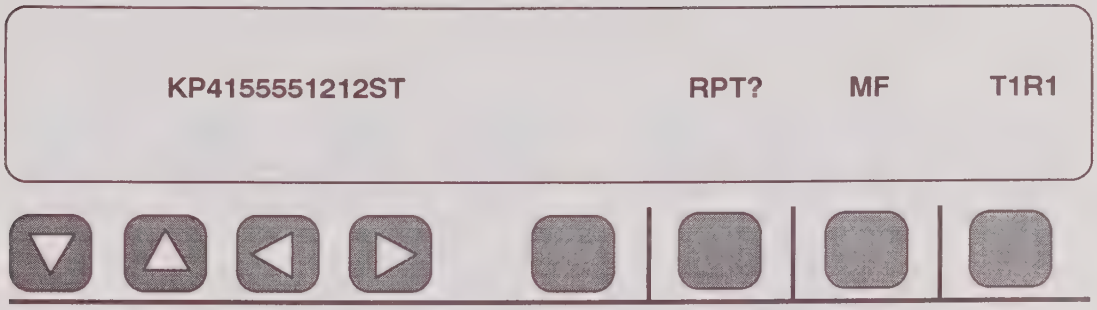
Store this sequence in location 11 by pressing the STO and ENT keys. Notice that the 930A automatically incremented the register location so that it was not necessary to enter the number 11.

Press the CLEAR CLR key to clear the display and allow entry of the next sequence.

The final string includes the called number (with Area Code). For this example the number used will be "4155551212". This will also be an MF sequence since this example is showing switch to switch connections. This does not have to be the case however, as any types can be mixed together in practice. To key in the above sequence:

Press KP * , then press 4 1 then press 5 four times, then 1 2 1 2 and finally, press ST #.

The 930A display will now look like:



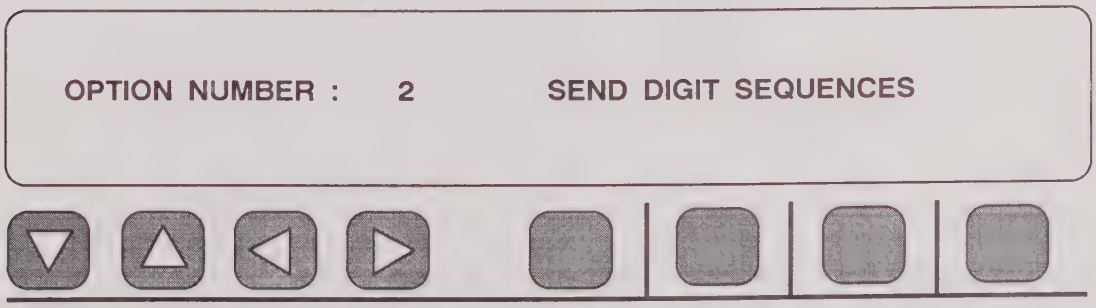
Store this sequence in location 12 by pressing the STO and ENT keys.

Having entered and stored the sequences to be outpulsed in this example, the next step is to go to the SEND DIGIT SEQUENCES function and set it up to actually do the outpulsing. To accomplish this, perform the following steps:

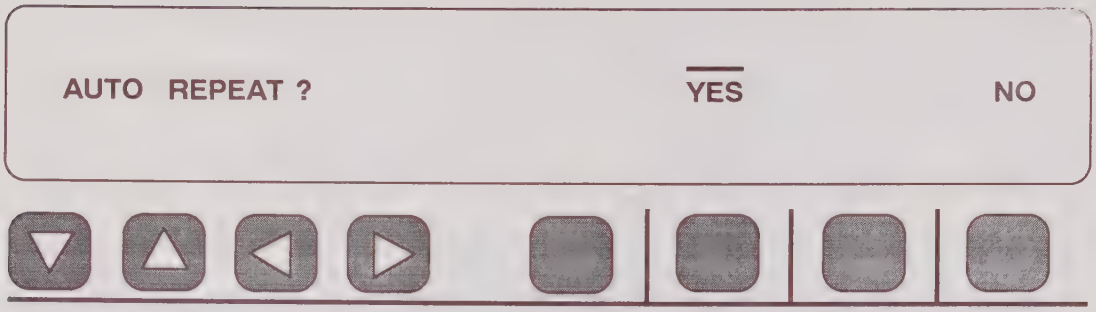
Press the OPTION MENU Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 2: SEND DIGIT SEQUENCES.

The 930A display should look like:



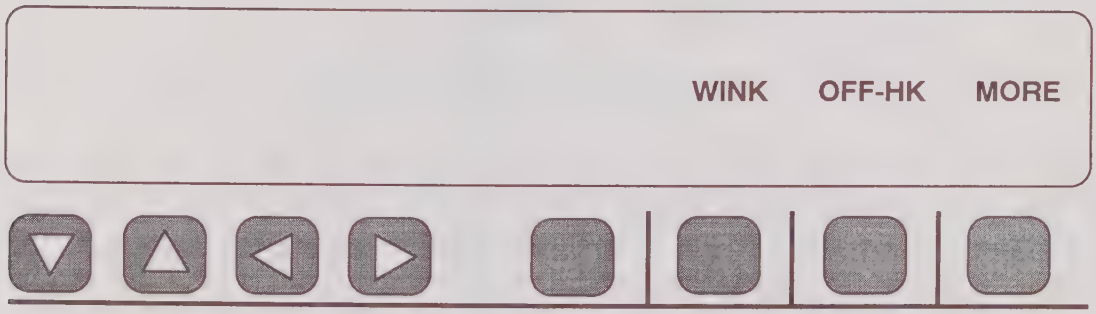
Press any Softkey to enter the menu option and the 930A display will change to:



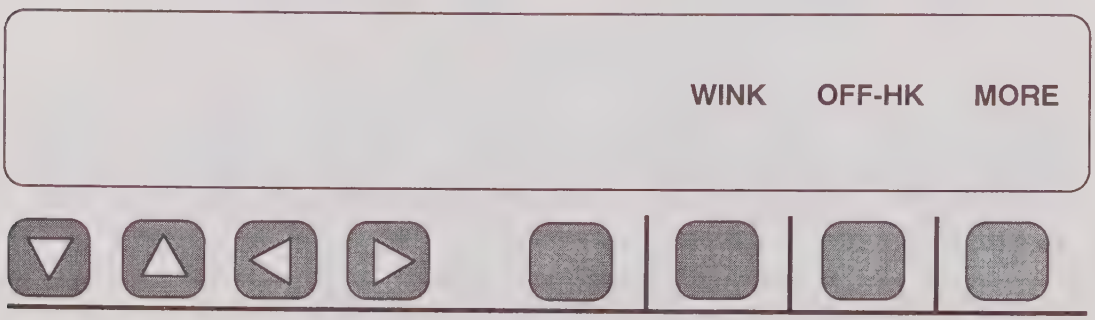
Pressing Softkey 2 will cause the 930A to continuously repeat outpulsing the sequence entered.

Pressing Softkey 4 will disable the auto repeat function and place the 930A in a manual mode.

Press the Softkey under the desired choice and the 930A screen will become:



If a previous test sequence is present, press the CLEAR CLR key and the display will show:



An Access Tandem simulation of a Feature Group D sequence consists of the previously stored IC Code number, the ANI or calling number, and the called number, separated by Wink supervision at the appropriate points. To input the sequence into the above display, do the following:

Press Softkey 2 which will instruct the 930A to wait for a Wink before outpulsing.

Press [1] and [0] and then [ENT]

This instructs the 930A to outpulse the digits stored in register 10.

Press Softkey 2 again to insert another wait for Wink between the IC Code number and the rest of the numbers. The 930A will then wait for the Wink.

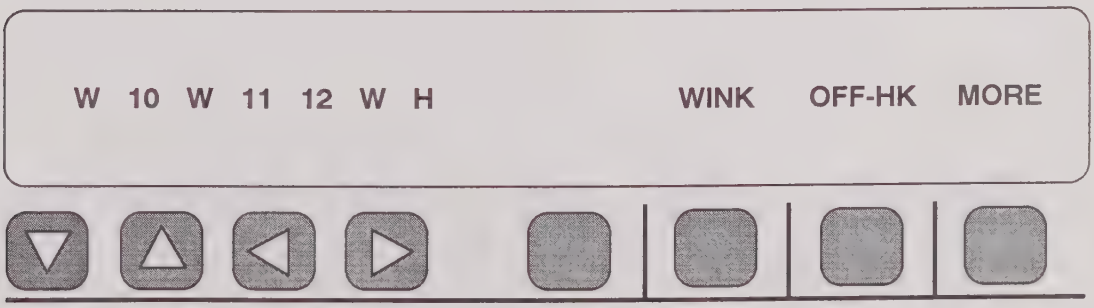
Press [1] twice and then [ENT]

Press [1] and [2] and then [ENT] .

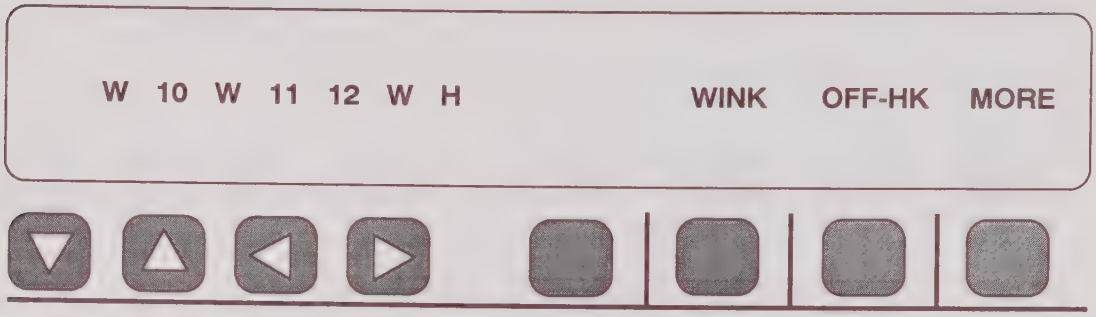
This instructs the 930A to outpulse the digits in registers 11 and 12.

Press Softkey 2 to instruct the 930A to look for the final Wink.

Press Softkey 3 to instruct the 930A to expect the far end to go "Off Hook".



The program is now complete and the display will be as follows:



where 10 = KP001777ST, 11 = KP00408761000ST,
and 12 = KP4155551212ST, in this example.

To execute the "program", place the front panel Hook Switch in the OFF-HOOK position and the sequence will be outpulsed. If the 930A is already OFF-HOOK, go back ON-HOOK and then go OFF-HOOK again and the sequence will be outpulsed. The operator can hear the outpulsing digit strings on the 930A's speaker and should also hear the far end answer. The Model 930A will also have automatically timed the winks. The wink timing can be examined by going to Menu Option 9: WINK TIMING. This menu option is discussed in Section 3-12.3.

The operator can either "send" multi-wink sequence from the 930A or "receive" a multi-wink sequence (described in Section 4-2.1) but cannot do both simultaneously from a single 930A. That is, a 930A cannot simulate the Originating and Terminating offices simultaneously. A full Equal Access test should be an end-to-end test with a 930A at each end so that digit sequences can be sent and received in both directions of transmission.

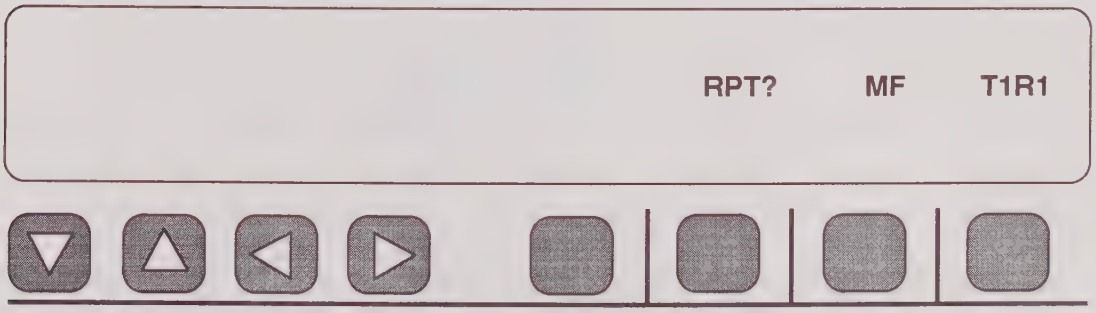
3-12.2.2 SENDING A SEQUENCE ON A WINK START TRUNK

Another typical example of originating a call from the 930A involves the very common wink start trunk. On an E&M trunk between offices or a T-1 carrier interoffice trunk, it is most commonly a wink start trunk. That is, the originating office will not send digits to the terminating end until it receives a wink from the terminating end office indicating that it is all right to proceed.

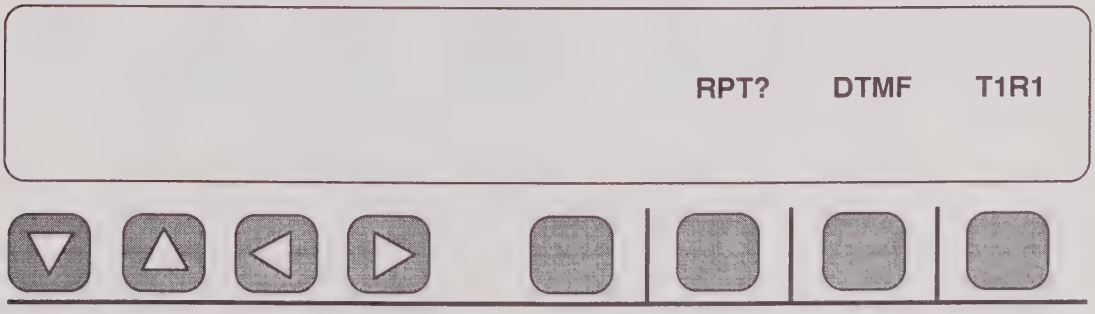
For this example, assume that a DTMF sequence is to be sent on a wink start trunk. As in the previous example, it is necessary to first store the desired phone number in one of the memory locations (01 to 39) from the DIAL/RING function. To repeat the process:

Press the DIAL/RING Dial/ Ring function key.

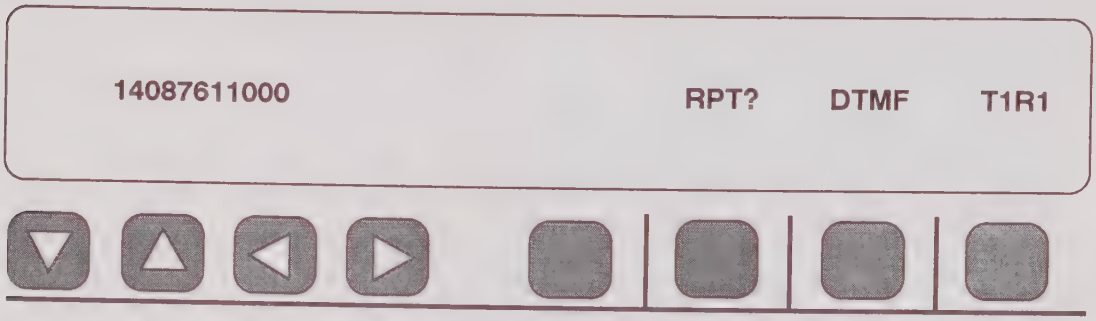
The 930A display below is a typical example:



In this example, it is desired to outpulse in DTMF, not MF, so pressing Softkey 3 (under MF) will change the display to:



The next step is to enter the desired telephone number using the numeric keypad. A typical display after entering a number is shown below:

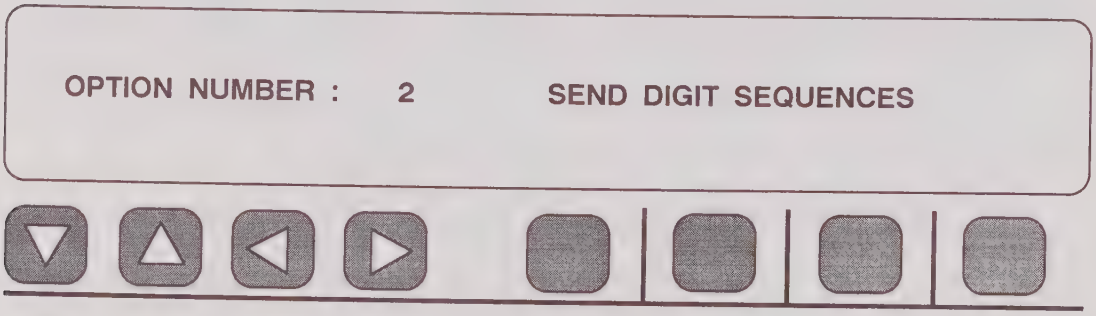


Using the same procedure employed in the previous example, store the above number in register location 20 for example. After pressing the STORE key, entering 2 and 0, and pressing the ENTER key, the 930A display will return to the above display. At this point, perform the following steps:

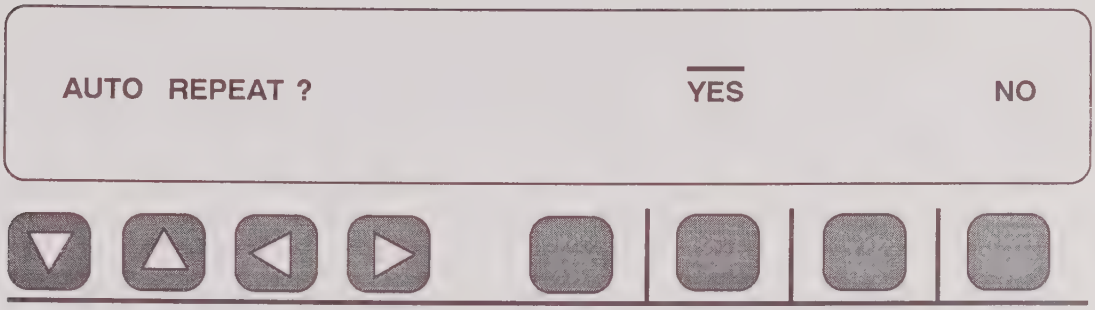
Press the OPTION MENU **Option Menu** function key.

Use the UP/DOWN arrow keys to select Menu Option 2: SEND DIGIT SEQUENCES.

The 930A display should look like:



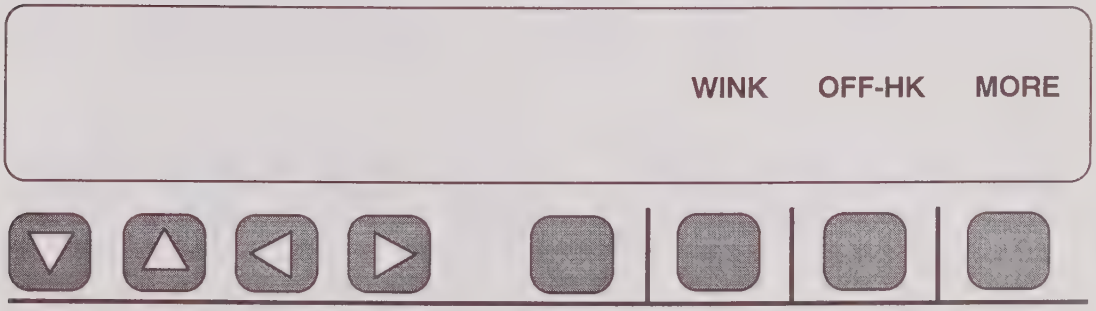
Press any Softkey to enter the menu option and the 930A display will change to:



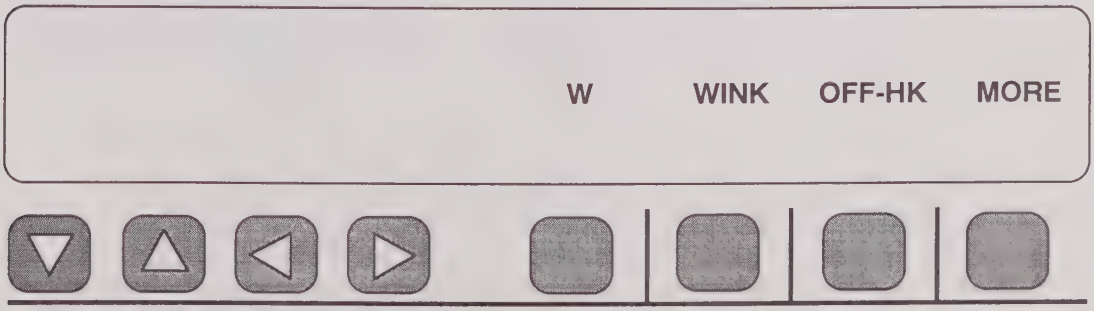
Pressing Softkey 2 will cause the 930A to continuously repeat outpulsing the sequence entered.

Pressing Softkey 4 will disable the auto repeat function and place the 930A in a manual mode.

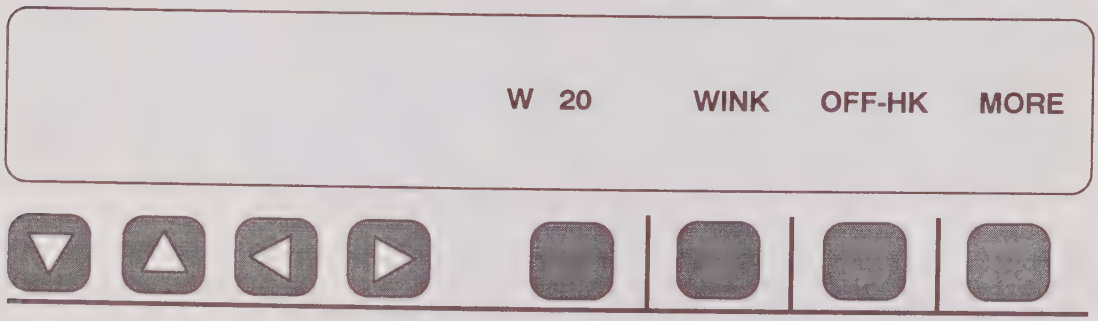
Press the Softkey under the desired choice and the 930A screen will become:



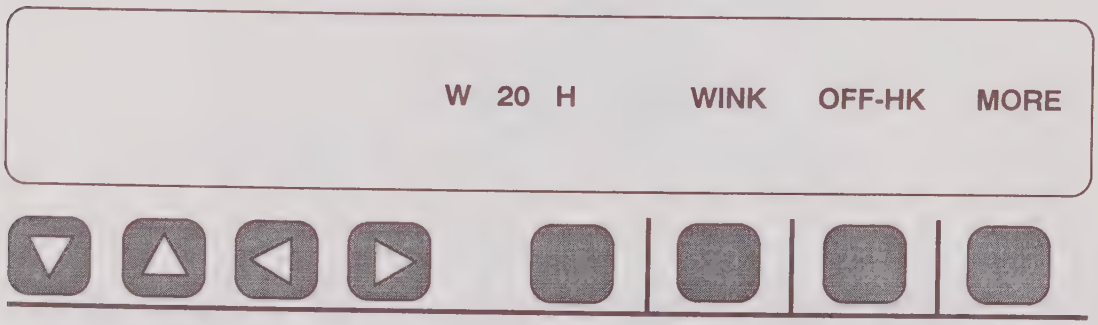
To program the 930A to wait for a wink before outpulsing, press Softkey 2 (labeled WINK in the above display) and the 930A display will become:



The next step is to enter the location of the memory register where the phone number to be outpulsed is located. In this example, the number to be outpulsed after the wink is received was stored in memory location 20. Press 2 and 0 on the numeric keypad and then press the ENTER key and the 930A display will be:



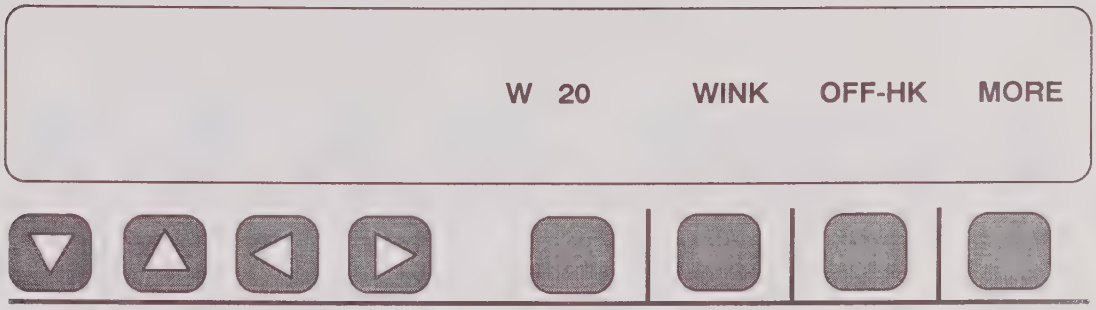
If it is desirable, an OFF-HOOK indication can be inserted at the end of the sequence to look at answer back supervision. In that case, press Softkey 3 (labeled OFF-HOOK above) and the display will change to:



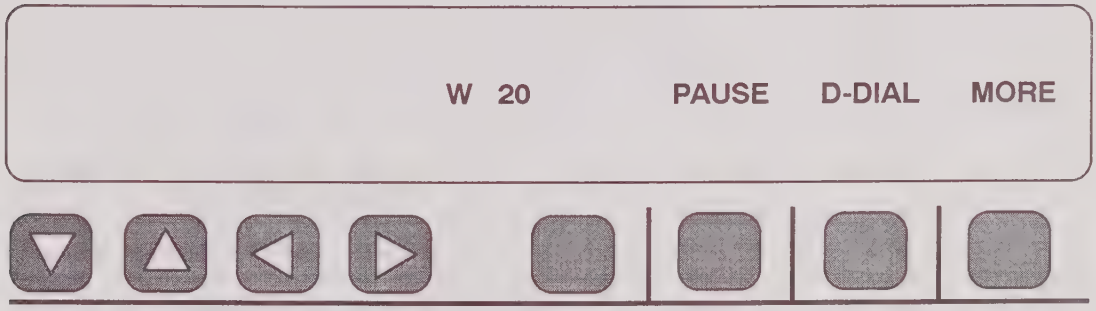
To outpulse the telephone number then, all that is required is to place the front panel hook switch in the OFF HOOK position and the 930A will seize the trunk, wait for a wink and then outpulse the digits.

Instead of looking for an OFF HOOK at the end of the sequence, suppose that it was desirable to enter a pause instead. In this case, go back to the 930A display before the OFF HOOK was entered.

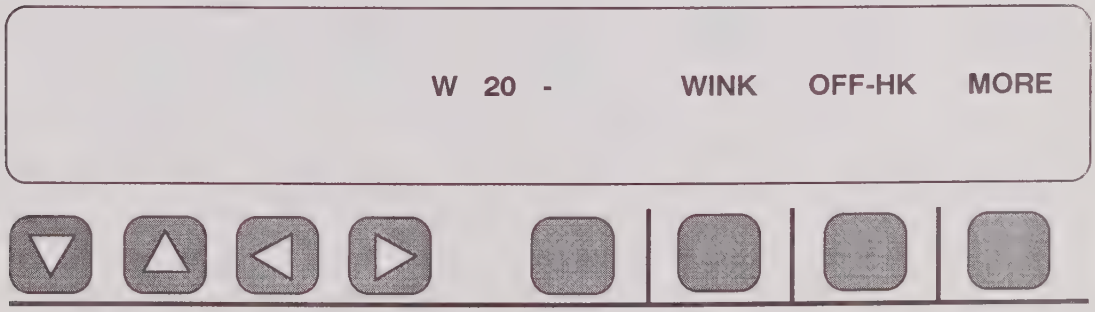
The display is repeated below:



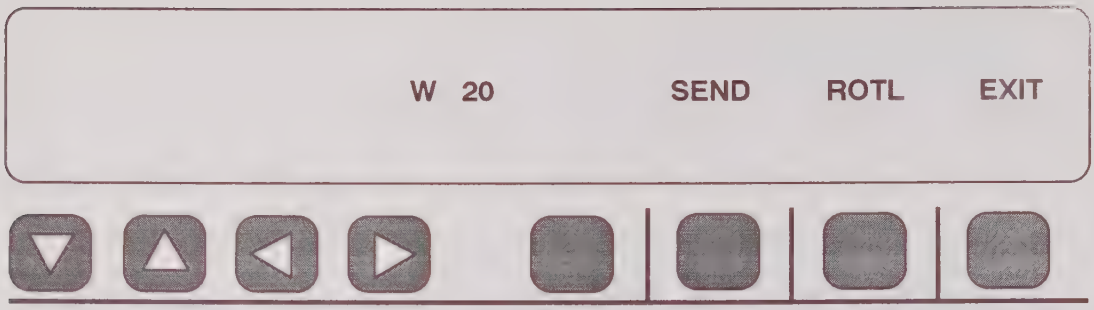
Instead of pressing Softkey 3, press Softkey 4 and the 930A will advance to the next display:



From this menu the operator can enter the Pause by pressing Softkey 2 and the 930A display will become:

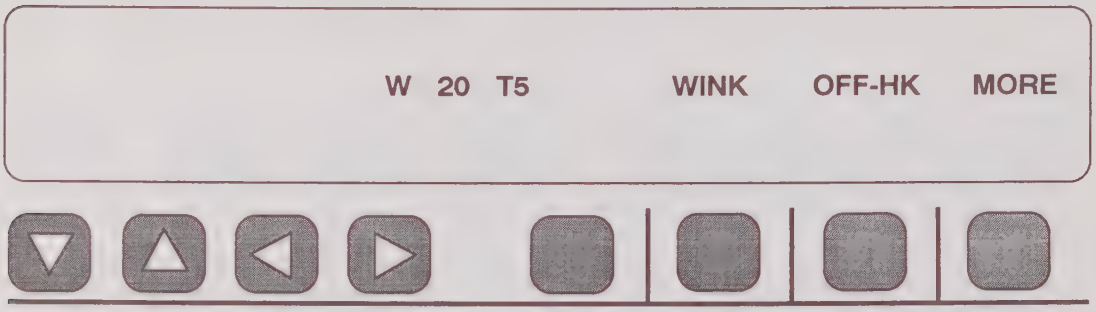


This menu would outpulse the digits stored in location 20 after going Off-Hook and receiving a wink and would then pause for one second after outpulsing. More likely the user would tack something on to the sequence after the pause. Pressing Softkey 4 instead of entering a pause would bring up the last selections:



This menu would enable sending the sequence without going off-hook or having the 930A act as a Remote Office Test Line (ROTL)/Near End Responder at the end of the sequence.

For example, if it was desired to have the 930A act as a ROTL/Near End Responder at the end of outpulsing the number of the far end responder, then pressing Softkey 3 would change the display to:



To begin outpulsing, go Off Hook using the front panel switch and the 930A will outpulse the contents of register 20 after it receives a wink from the far end. In the above example, the 930A would then interrogate the far end Type 105 responder and display the results of the two way measurements. The operation of this option (option 930A-12) is explained in greater detail in Section 4-7.2.1.

3-12.3 MENU OPTION NUMBER: 9 WINK TIMING

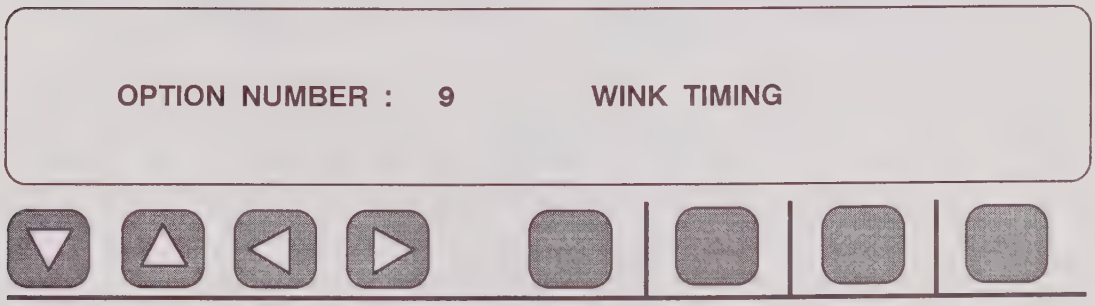
Menu Option 9: WINK TIMING is used with Menu Option 2: SEND DIGIT SEQUENCES or with Menu Option 4: DIGIT RECEIVER (If Option 930A-01 has been purchased). Menu Option 9 enables timing of Supervision events.

To use Menu Option 9, first outpulse a multiple record sequence such as that used as an example in Section 3-12.2. That sequence expected a Wink and also expected the far end to go Off-Hook. The procedure for outpulsing the sequence is described in detail in Section 3-12.2. Perform the following steps to get to Menu Option: 9 WINK TIMING:

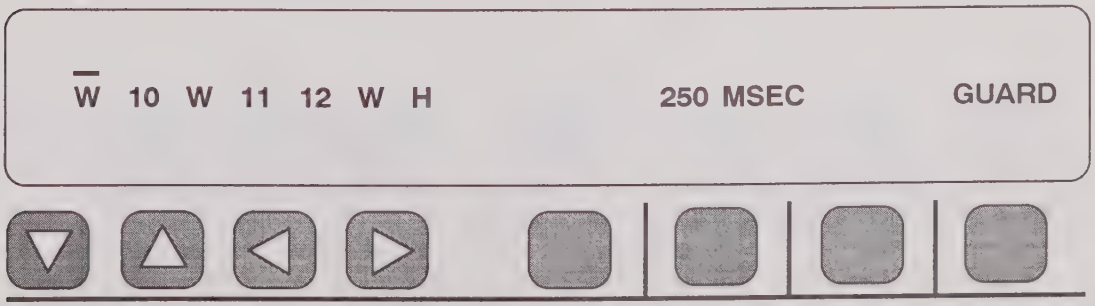
Press the OPTION MENU Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 9: WINK TIMING.

The 930A display will show:

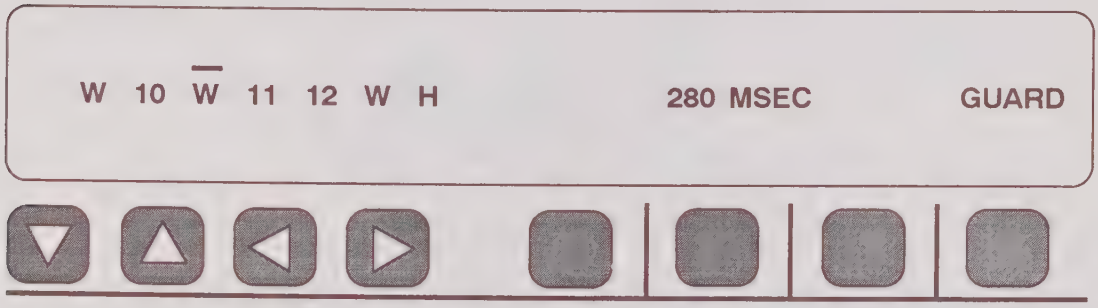


Enter the menu option by pressing any Softkey. The display will show the sequence as it was keyed in under SEND DIGIT SEQUENCES. For example, if the sequence from Section 3-12.2 is used, the display will appear as:



A flashing cursor will appear over the last completed wink or Off-Hook in the sequence. If a wink or Off-Hook has failed, the cursor will appear over the failed event. If the sequence has not yet been outpulsed, the cursor will appear over the first supervision event and all measurements will be zero. There will be a measurement, "NNNN MSEC", where NNNN is the length of time in milliseconds spent waiting for the event (the Guard Time). The word "GUARD" is displayed to label the measurement.

The Left and Right arrow keys allow the user to move the cursor within the multiple record sequence to examine any supervision event. For example, the user may want to examine the second wink in the sequence above. Using the Right arrow key, move the cursor over the second wink and the display will appear as shown below:



The measurement always refers to the event under the cursor. The operation of the softkeys is as follows:

Softkeys 1 - 3 are inactive.

Softkey 4 is a wheel enabling the user to select that portion of the supervision event to be examined. If the event is a WINK, it selects between Guard time and Wink time. If the event is an Off-Hook, it selects between Guard time and the length of time Off-Hook.

The Guard period is measured in milliseconds. If the Guard period exceeds 16 seconds, the event "fails". In such a case the guard measurement display would read ">16000 MSEC", and the wink or off-hook measurement would read "FAILED". The wink period is also measured in milliseconds.

If the event is a wink, it fails if the period exceeds 600 msecs. If the event is an off-hook, it fails if this period is less than 200 msecs. The operator may also use Wink Timing to measure Delay Dial events. A Delay Dial event fails if the Guard period exceeds 16 seconds, or if the off-hook period exceeds 16 seconds.

3-12.4 MENU OPTION NUMBER: 10 FREQUENCY SWEEP

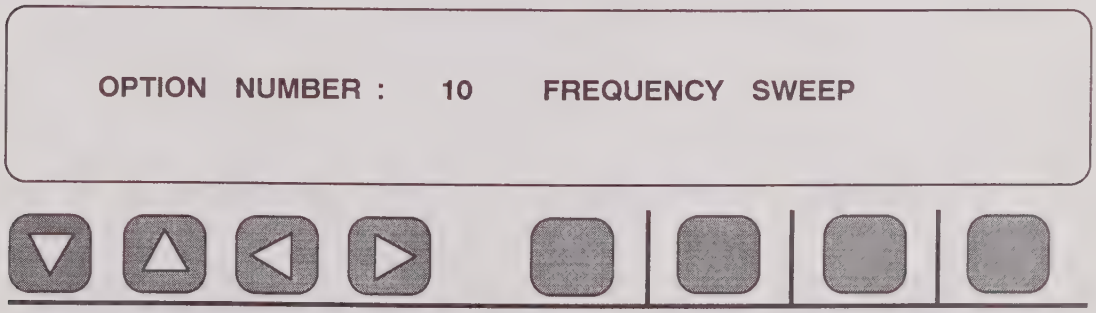
Menu Option 10, FREQUENCY SWEEP, is a standard feature on all Model 930A's. This menu option permits the operator to set the 930A to sweep up or sweep down in frequency either one time or continuously. The frequency limits, step size, amplitude and sweep times are user selectable for maximum flexibility. In addition, the user may set the 930A to either skip or not skip the SF frequency during the sweep as desired.

Prior to attempting to set up the frequency sweep, the user should set the 930A to the appropriate trunk type using the procedures in Section 3-6 or Section IV for optional trunk types. To set up the 930A frequency sweep function, perform the following steps:

Press the OPTION MENU **Option Menu** function key.

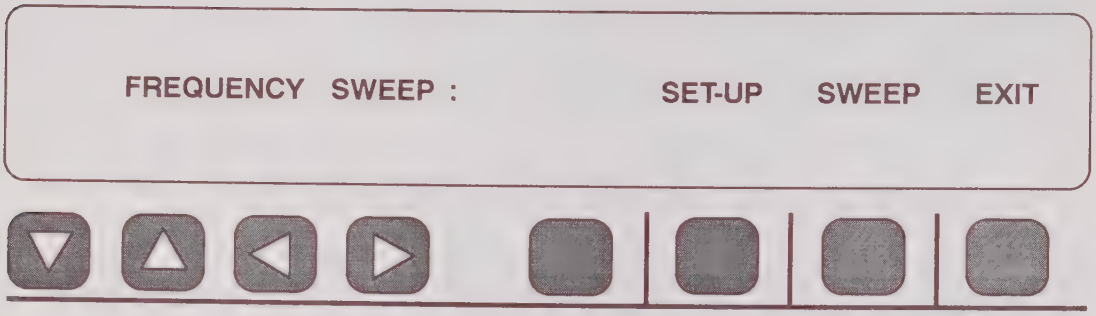
Use the UP/DOWN arrow keys to select Menu Option 10: FREQUENCY SWEEP.

The 930A display will appear as shown below:



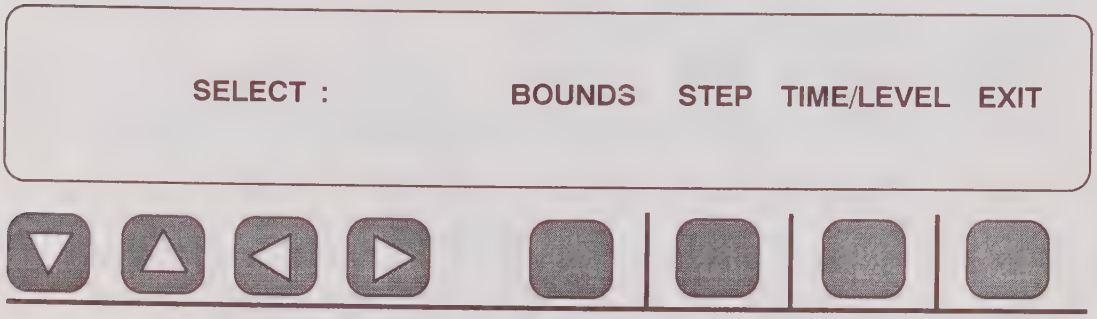
Pressing any Softkey will enter the menu option.

Once inside menu option 10 the 930A display will be as shown below:



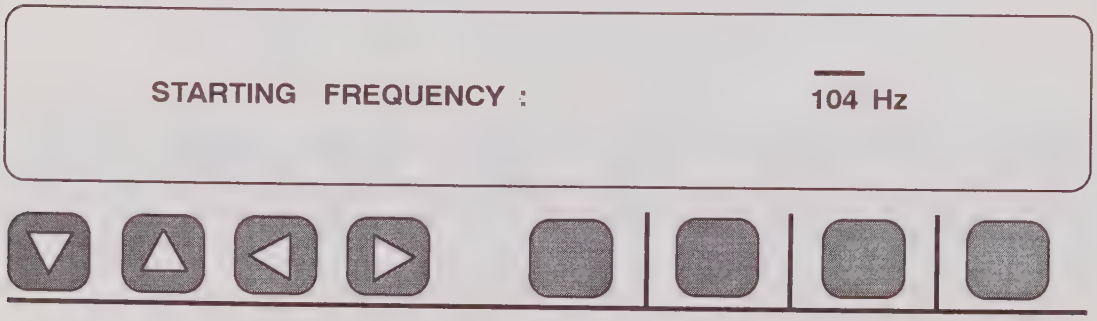
The 930A retains any set-ups previously input so that it is not normally necessary to go through the set up process each time the sweep function is used unless it is desired to change the parameters. For purposes of description the set-up procedure is described below.

Press Softkey 2 (labeled SET-UP) and the 930A display will appear as shown below:

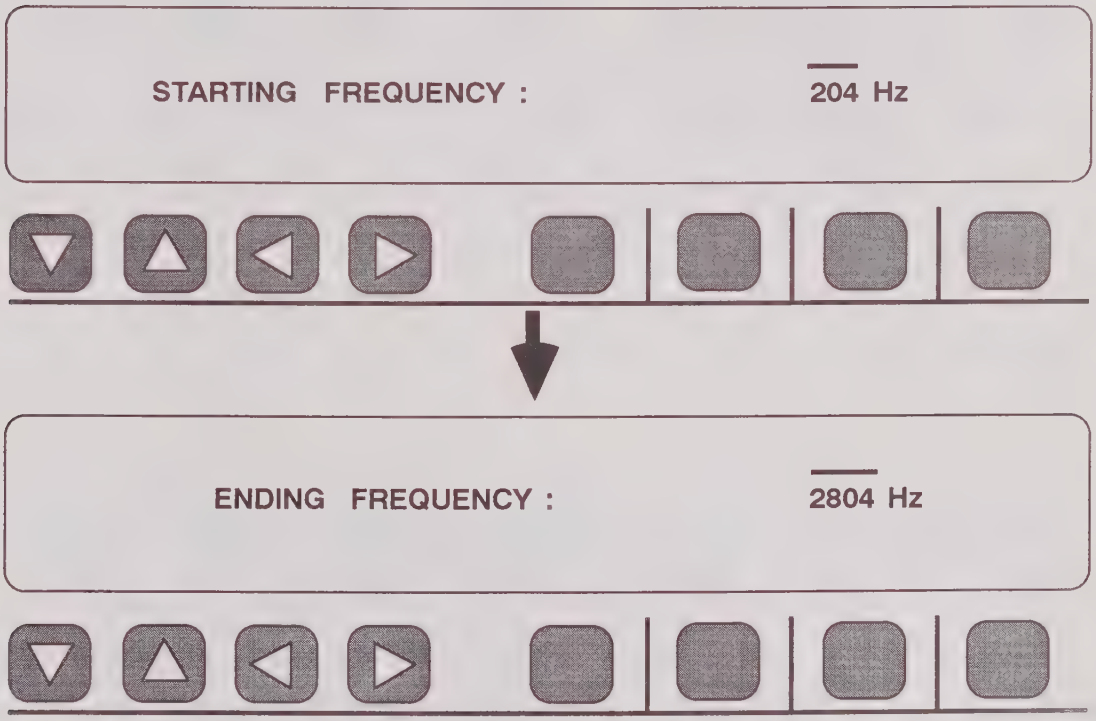


The following procedure outlines the steps to set-up the 930A sweep function for a common frequency sweep (204 Hz to 3904 Hz with SF skip).

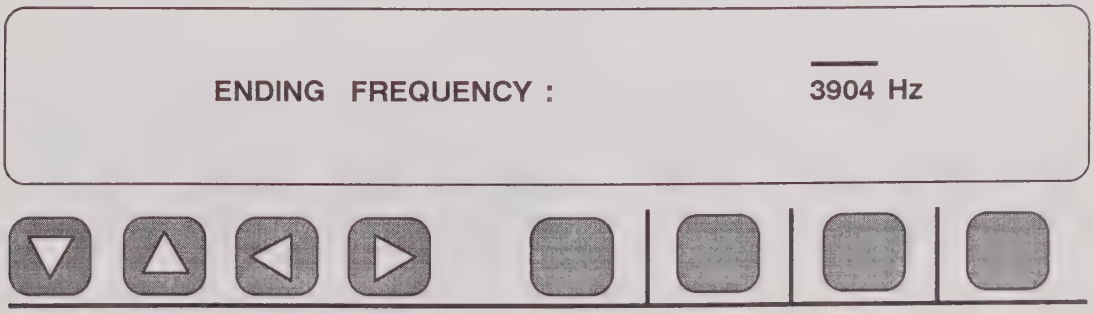
Press Softkey 1 (labeled BOUNDS) and the 930A display will show the last starting frequency used.



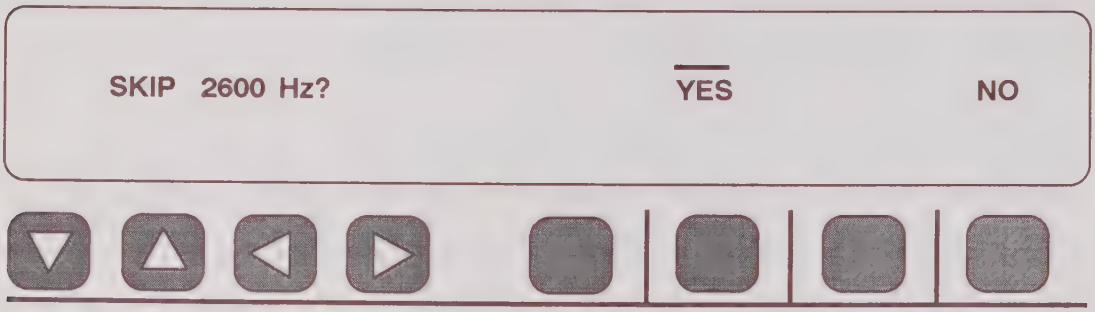
In this case, 104 Hz had previously been used as the starting frequency. It is desired to have the 930A sweep up from 204 Hz to 3904 Hz so it is necessary to enter a new starting frequency of 204 Hz instead of the current 104 Hz value. To do this use the numeric keypad to enter the sequence "0", "2", "0", "4" and then press the ENTER key or Softkey 3 to enter the 204 Hz value and the 930A display will immediately enter the value and proceed to ask the user to enter the ending frequency desired in rapid succession as shown below:



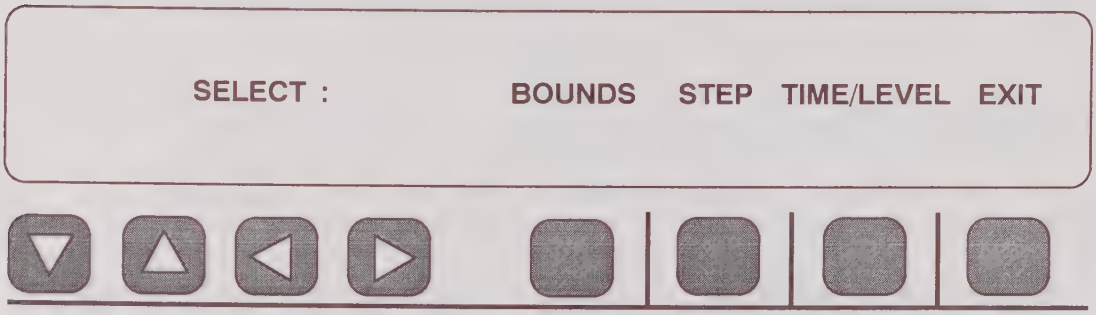
The desired ending frequency is 3904 Hz so use the numeric keypad to enter the sequence "3", "9", "0", "4" and press the ENTER key or Softkey 3 to enter the 3904 Hz value. The display will momentarily show the new value as:



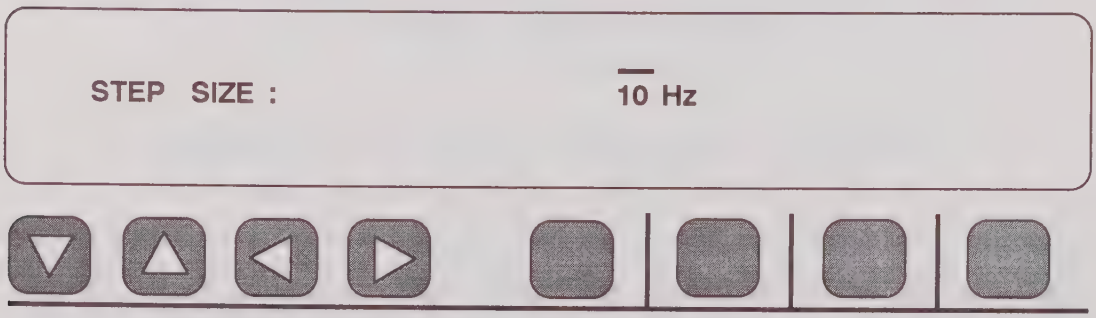
The display immediately changes to the following after entering the ending frequency:



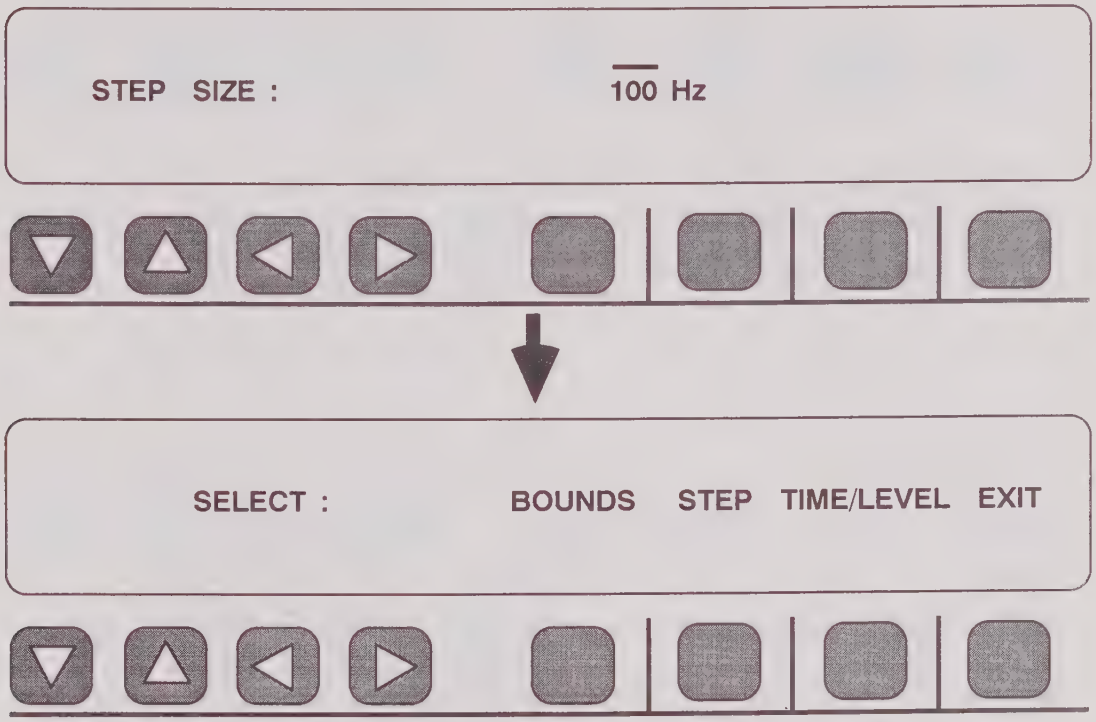
In this case the 930A is asking whether the operator wants to skip the SF frequency (actually skips 2450 Hz to 2750 Hz) or not. For this example it is desired to skip the SF so Softkey 2 is pressed and the display reverts to the selection menu display as shown below:



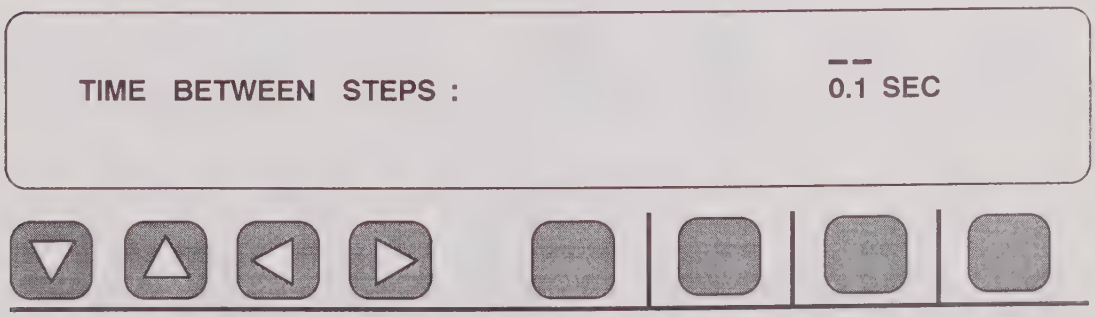
Now that the frequency bounds have been set, the next item is setting the frequency step size of the sweep. The 930A allows step sizes from 1 Hz to 999 Hz but the most common step size is 100 Hz. Press Softkey 2 (labeled STEP) and the 930A display becomes:



Since a step size of 100 Hz is desired the operator must use the numeric keypad to enter the sequence "1", "0", "0" and then press the ENTER key or Softkey 1 and the 930A will momentarily show the new step size and then return to the selection menu as shown below:

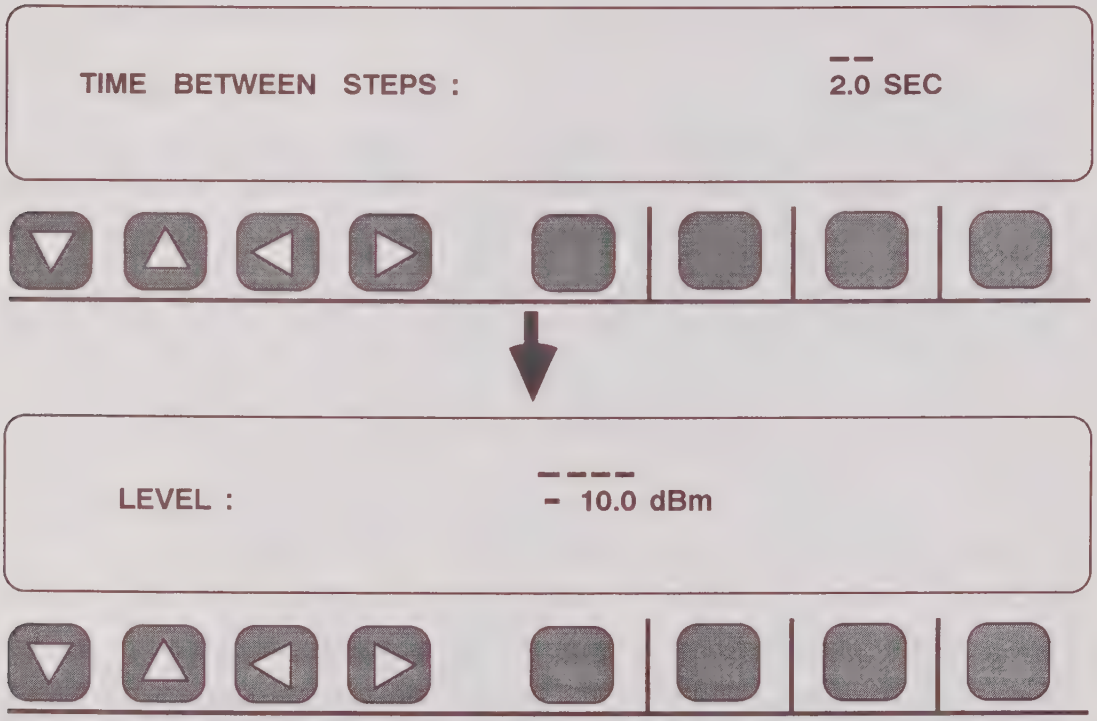


The next step is to select the sweep time between steps and the level at which the tones are to be sent. Press Softkey 3 (labeled TIME/LEVEL) and the 930A display becomes:

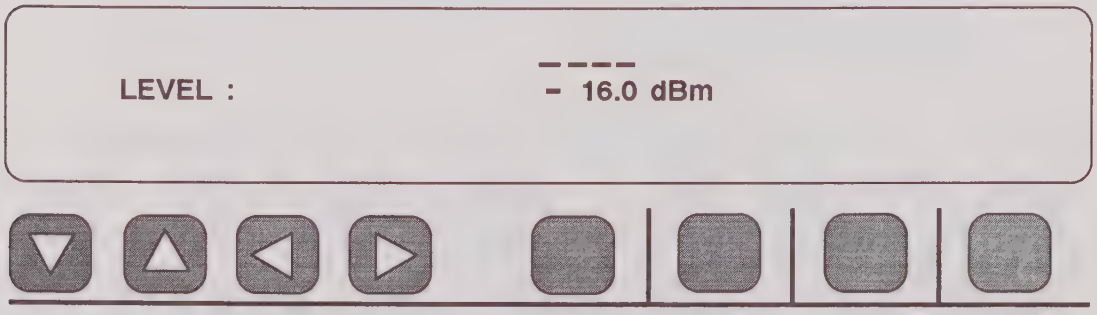


The 930A allows the user to select sweep times from 0.1 seconds to 9.9 seconds. A reasonable value which allows for instrument settling time as well as operator convenience is about 2 seconds.

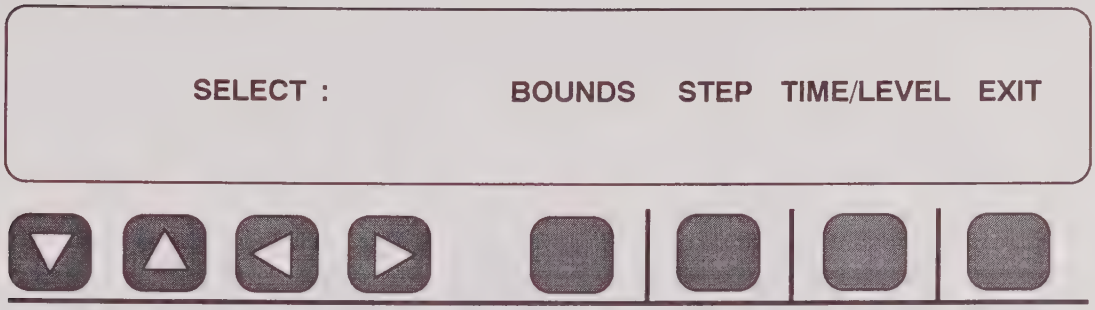
To enter a value of 2 seconds, use the numeric keypad to enter the sequence "2" and "0" and the press the ENTER key or Softkey 3 and the 930A will immediately enter the value and change to the level select display as shown below:



Although -10 dBm is a common level let us assume for this example that a value of -16.0 dBm is desired. Use the numeric keypad to enter the sequence "1", "6" and "0" and then press the ENTER key or Softkey 1 to enter the value and return to the selection menu as shown below:

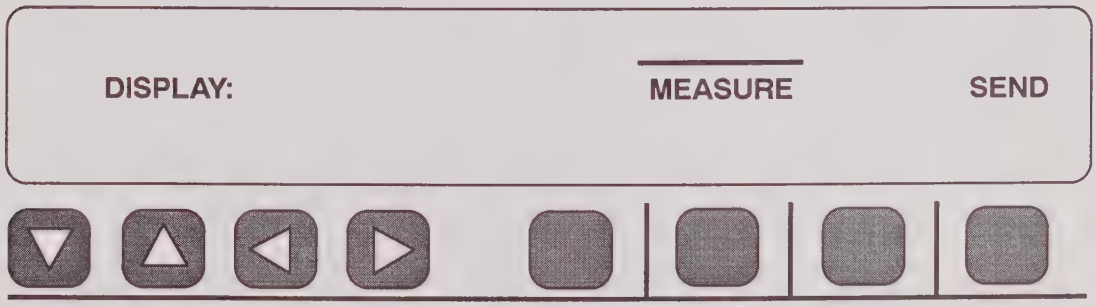


This display immediately changes to the selection display.



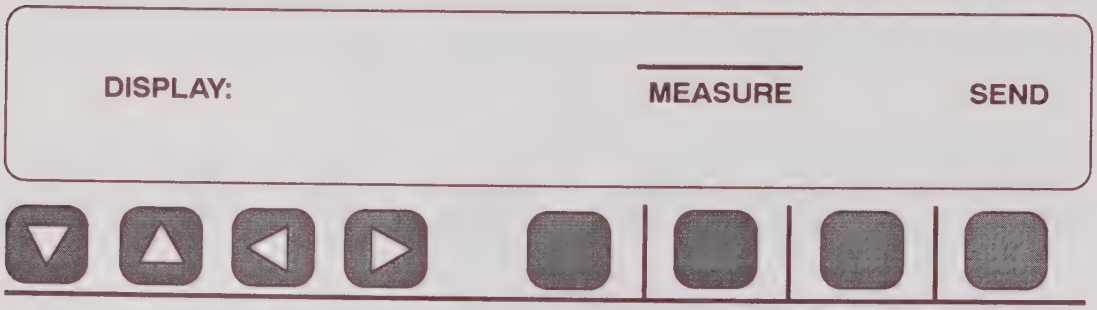
Once all of the parameters have been set in for the desired sweep, press Softkey 4 (labeled EXIT) to return to the main sweep menu shown below.

Pressing Softkey 3 (labeled SWEEP) causes the 930A to display the following:

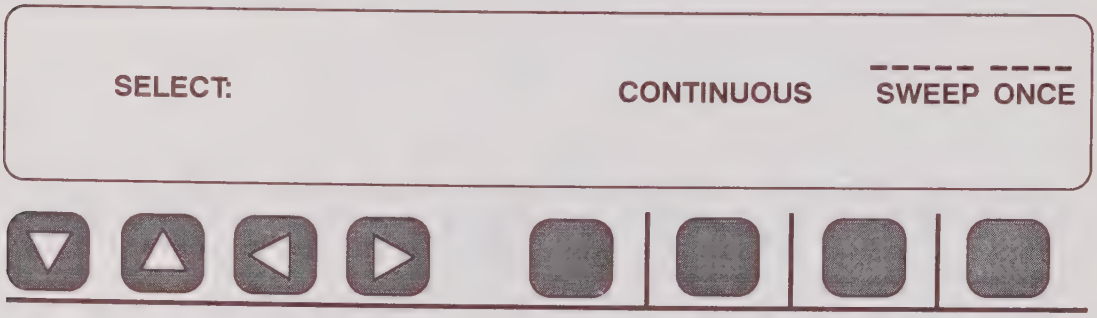


The flashing cursor appears over the previous selection. The two choices are MEASURE and SEND. The MEASURE mode enables the 930A to send and receive the sweep frequencies chosen during the set-up procedure. This mode is chosen when loopback testing from a single end is being performed. The SEND mode simply sends the sweep frequencies out from the 930A but does not receive anything while the sweep is being performed. This would be used only for end to end measurements where there was another test set receiving the sweep at the far end.

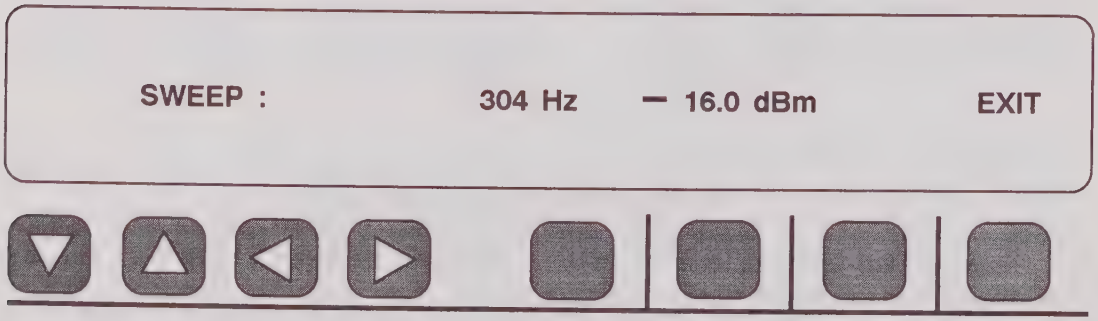
Repeating the previous display below, the choices are MEASURE and SEND.



Pressing Softkey 2 will select the **MEASURE** mode and the 930A display will immediately change to the following:

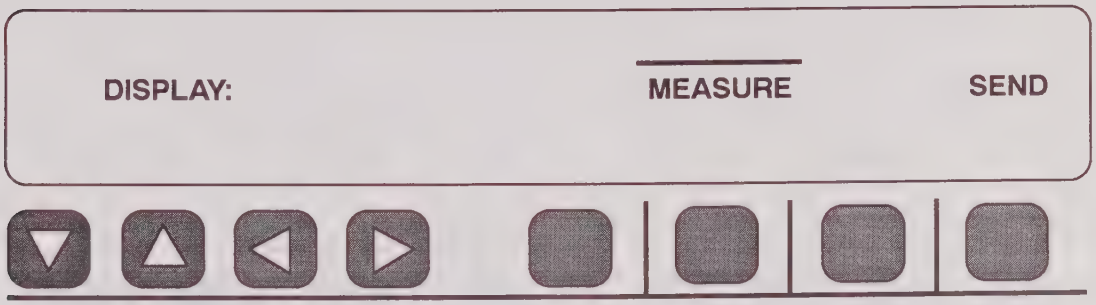


In this display the user is asked to choose between a single sweep or a continuous repetition of the sweep. Pressing Softkey 2 chooses continuous sweep and Softkey 4 chooses single sweep. If either key is pressed, the 930A immediately begins to send tone from the start frequency provided that the front panel Hook Switch has been placed in the OFF HOOK position. If the far end has been looped back then the 930A display will show the received frequency and level. An example of such a display is shown below:

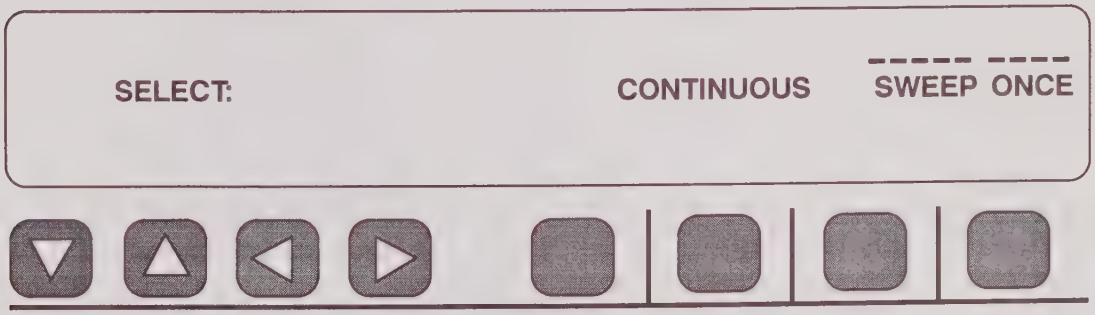


In the **MEASURE** mode, this is the received level and frequency. The 930A may be sending at -10 dBm which would indicate a two way loss of 6 dB at 304 Hz in this case.

However, if the user chooses the SEND mode of operation, then the 930A display shows the outgoing tone level and frequency. Repeating the set-up display below:

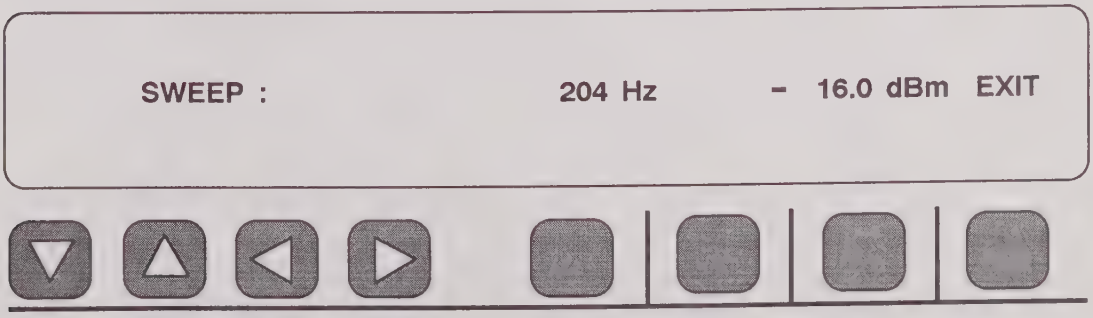


Pressing Softkey 4 in the display above chooses the **SEND** mode of operation. This is a send only mode in which the 930A is sweeping through a band of frequencies which the operator has selected and is not measuring anything. After pressing Softkey 4 the 930A display again becomes:

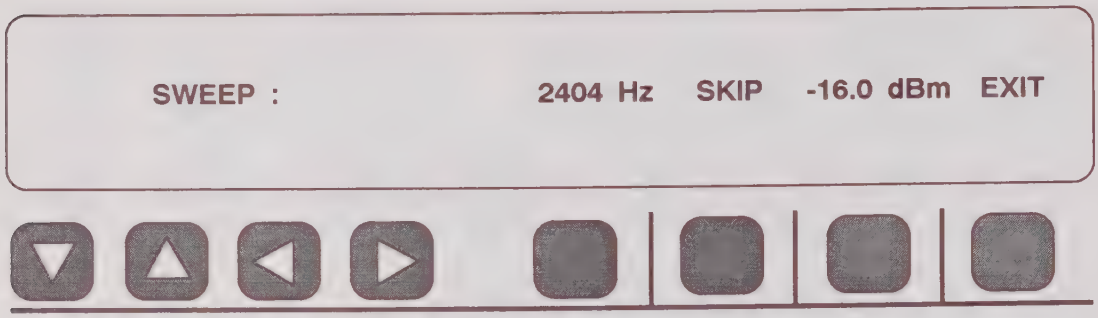


Press Softkey 2 to continuously sweep through the band of frequencies selected, or press Softkey 4 to sweep once and then stop.

When sweeping, the 930A display might appear as shown below to begin:



The display would, using the example set-ups, increment by 100 Hz starting at 204 Hz and proceeding to 304, 404 and so on. Since SF skip was also chosen, the 930A would hold at 2404 Hz and pick up the sweep at 2804 Hz in this case. The 930A display alerts the user to the fact that SF is being skipped by showing the word SKIP as shown below:



Some final points about the Frequency Sweep menu option follow. The user may choose to sweep down in frequency (in this example the sweep was up in frequency) by simply making the starting frequency the higher frequency and letting the ending frequency be the lower. The 930A will then figure out that the operator wants to sweep down instead of up. The rest of the procedure is the same as that described in the example above. If a single sweep is chosen the 930A will revert to the main sweep menu when the sweep has been completed.* The user may stop the sweep at any time by pressing Softkey 4 (labeled EXIT) or the Option Menu key itself.

* If a continuous sweep is selected, the sweep will repeat until the operator manually stops it by pressing the OPTION MENU function key.

3-12.5 MENU OPTION NUMBER: 30 ADJUST TLP

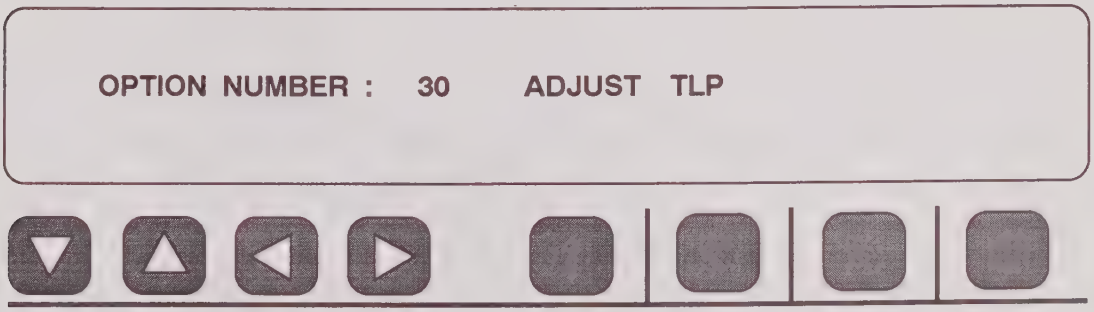
Menu Option Number: 30 ADJUST TLP provides the operator with a means of manually adjusting the transmission level point (TLP) compensation of the 930A and is a standard feature. The Transmit TLP affects the level of digits sent by the 930A. The Receive TLP affects the level sensitivity of the 930A's digit receiver. This function would not normally be used when testing PCM (T-Carrier) trunks since these are always a 0 dB TLP by definition.

To manually set the TLP level of the transmit or receive section of the 930A, perform the following steps:

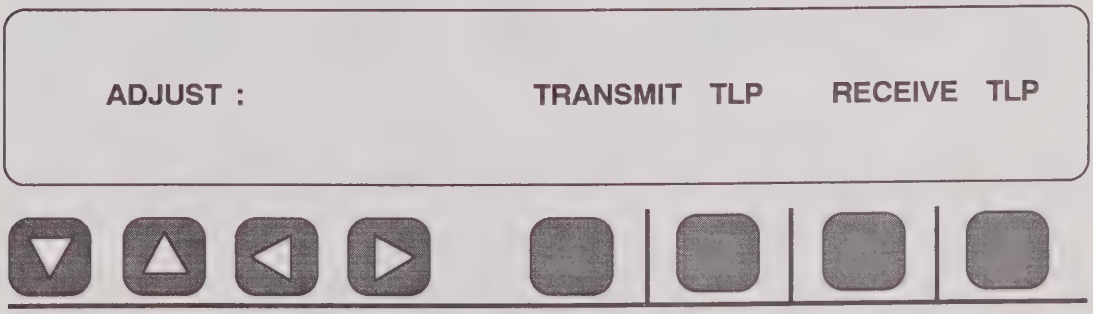
Press the OPTION MENU **Option Menu** function key.

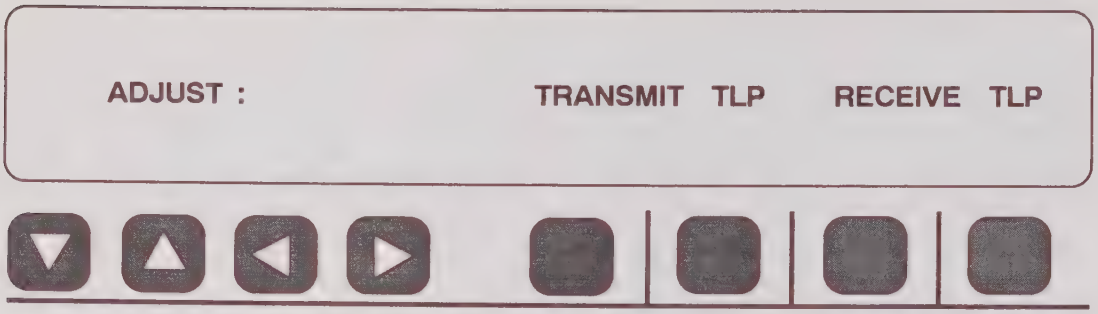
Use the UP/DOWN arrow keys to select Menu Option 30: ADJUST TLP.

The 930A display will appear as shown below:



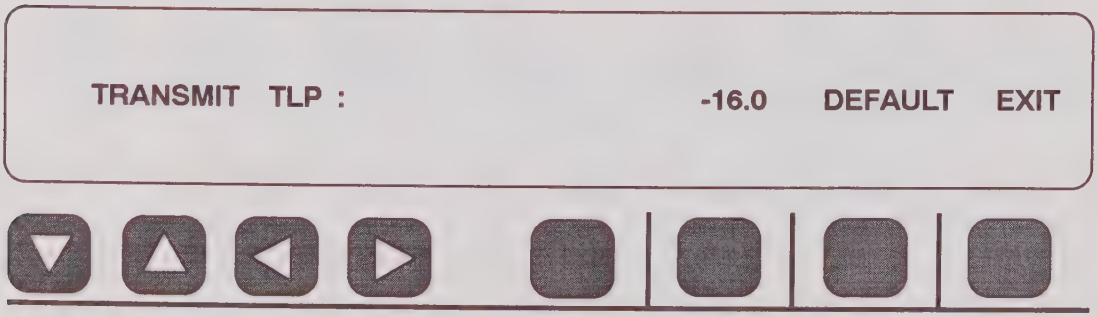
Pressing any softkey will enter the menu. Once inside menu option 30 the display will appear as:





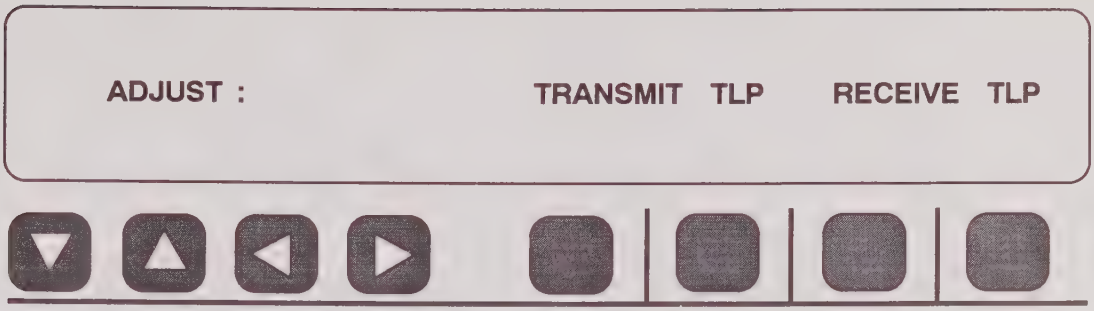
To adjust the Transmit TLP, press Softkey 1 and the 930A display will become for example:

In this case the previously entered TLP was 7.0 dB. If, for example, it is desired to manually set the transmit TLP to -16.0 dB then the operator must press Softkey 2 to scroll through the TLP values until -16.0 appears as shown below. The 930A sends digits at 7 dB below the Transmit TLP.

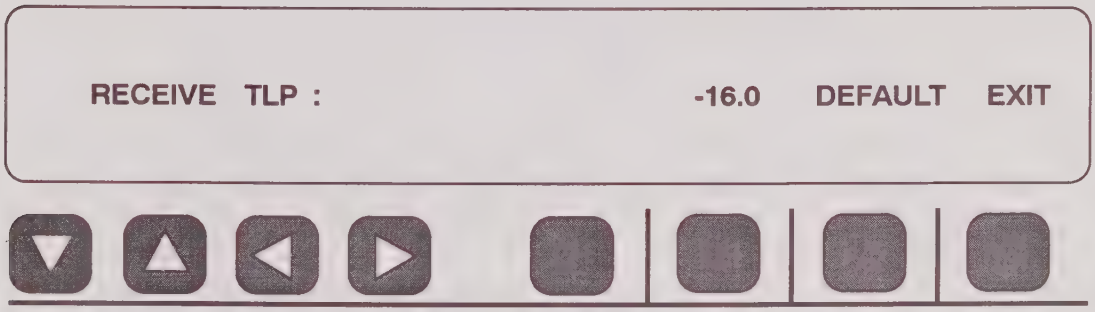


To return the 930A to the default TLP value for the trunk type selected, simply press Softkey 3 labeled "DEFAULT" and the 930A display will then show the appropriate value.

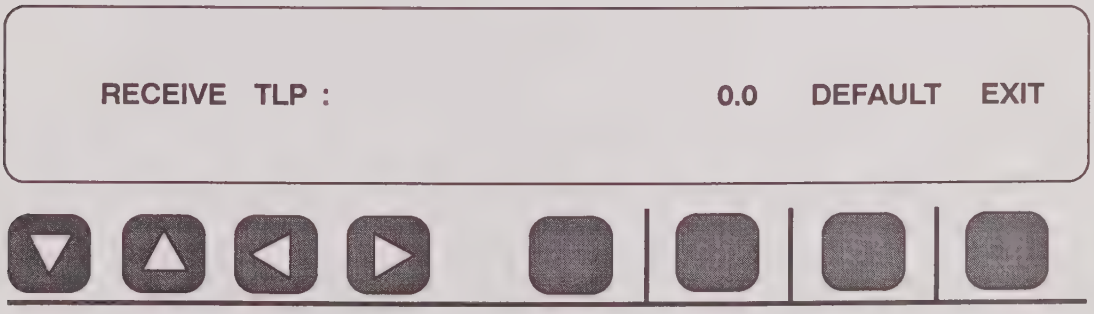
Press Softkey 4 labeled "EXIT" to return to the ADJUST menu.



Changing the Receive TLP affects the level sensitivity of the 930A digit receiver. If the operator desires to change the Receive TLP, pressing Softkey 3 will change the 930A display to:



If the displayed TLP value (-16.0 dB in this example) is not desired, simply press Softkey 2 to scroll through the other choices until a suitable value is displayed. For example suppose that a 0 dB TLP is desired. Pressing Softkey 2 causes the 930A display to become:



To enter the TLP value simply press Softkey 4 to exit the menu. Pressing DEFAULT will show what the 930A default TLP value is for the trunk type selected. Press the Option Menu function key to exit from the Adjust TLP function.

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3-12.6 MENU OPTION NUMBER: 15 BEEP ON ERROR

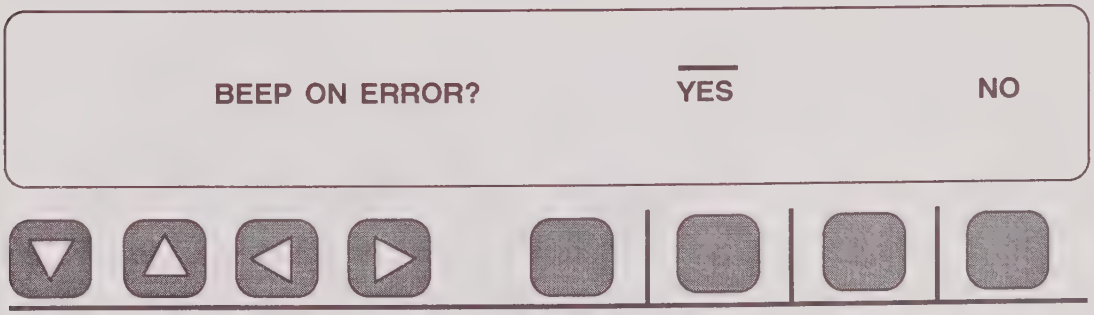
Menu Option 15: BEEP ON ERROR provides the operator with an audible indication of various types of errors. These include errors of commission such as selecting a trunk type option that has not been installed. Since there are times when the operator does not desire to listen to the beep, this option menu provides the means to turn off the beep without cutting the wires to it. To control the BEEP do the following:

Press the OPTION MENU **Option Menu** function key.

Use the UP/DOWN arrow keys to

to select Menu Option 15: BEEP ON ERROR.

Enter the option by pressing any softkey and the display will appear as:



If the cursor appears over the YES field then the BEEP has been turned on. To turn it off, simply press Softkey 4 and then any Function key to exit the menu. The user is now free to make all the operating mistakes he wishes without the annoying BEEP to disturb him. To turn the BEEP back on simply go back to Menu Option 15 and, once inside the menu, press Softkey 2.

If the user has ordered option 930A-10C (Remote Control), disabling the beep also prevents the 930A from sending the "Bell" character (ASCII 07) to a remote printer, terminal or computer.

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3-12.7 MENU OPTION NUMBER: 6 DC VOLTMETER

Menu Option 6: DC VOLTMETER provides the operator with a DC voltage measurement capability on metallic trunks. This function is most useful for determining the levels of supervision voltages on a loop. The most common supervision voltage is -48 VDC. However, there are PBX's in operation which do not put out exactly -48 VDC. Certain PBX's use -24 VDC while others use a varying voltage to achieve a constant current. It is also possible that a PBX may be connected to a very long loop which has too many ohms of resistance for the PBX to drive. The DC Voltmeter provides a means of determining the source of a problem.

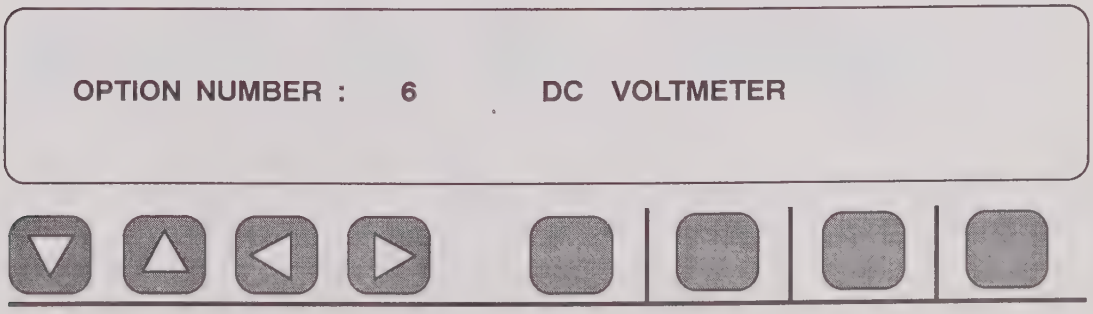
On 2W Loop and 2W Ground-Start trunks, the voltage from Tip-to-Ground, Ring-to-Ground and Ring-to-Tip may be inspected. On 4W Loop and 4W Ground-Start trunks, the voltage from TR-to-Ground, T1R1-to-Ground and TR-to-T1R1 may be measured. On E&M trunks, the voltage from E-to-Ground and M-to-Ground may be measured. All voltage readings are printed as signed values to the nearest volt. This feature may be used in either TERM or BRIDGE mode.

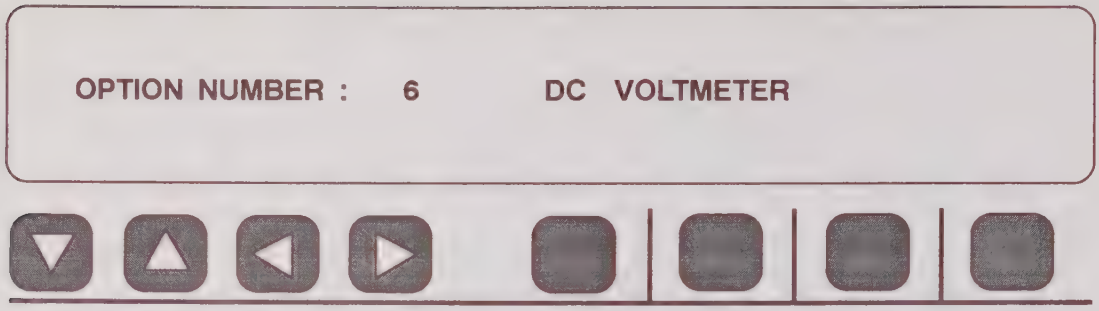
For example purposes, assume that the 930A is connected to a 2 Wire Loop Start trunk in the TERMinated mode. To measure DC voltage perform the following steps:

Press the OPTION MENU **Option Menu** function key.

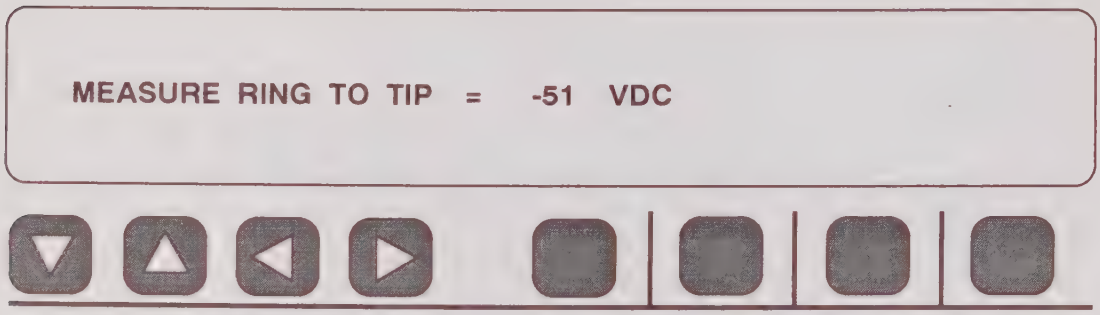
Use the UP/DOWN arrow keys to select Menu Option 6: DC VOLTMETER.

The 930A display will be:

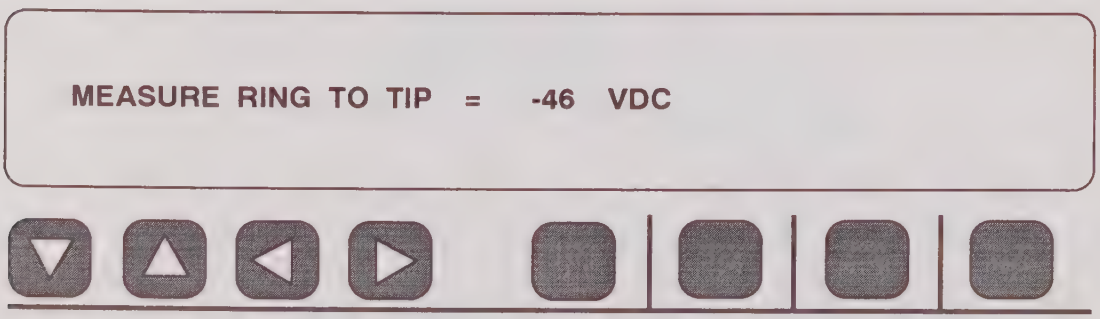




Enter the menu option by pressing any Softkey and the display will appear as:

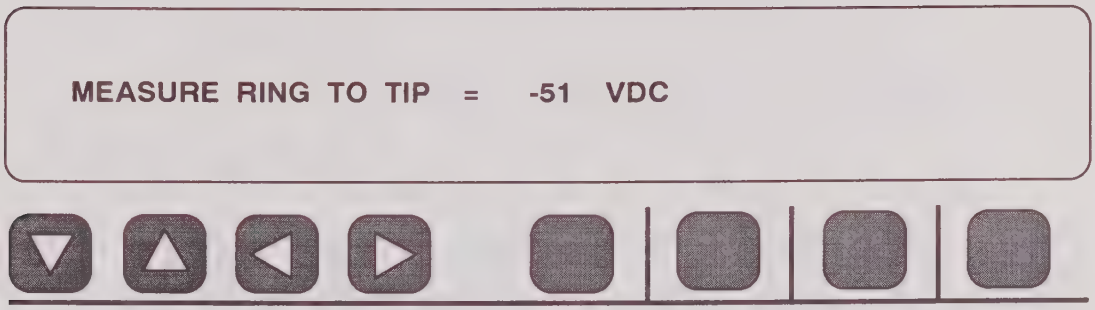


In this case, the contact side of the circuit is ON HOOK. If the contact side goes OFF HOOK then a lower reading will be expected as current is drawn through the loop and voltage drops occur. A typical display of Ring-to-Tip voltage after the contact side goes OFF HOOK might be as follows:

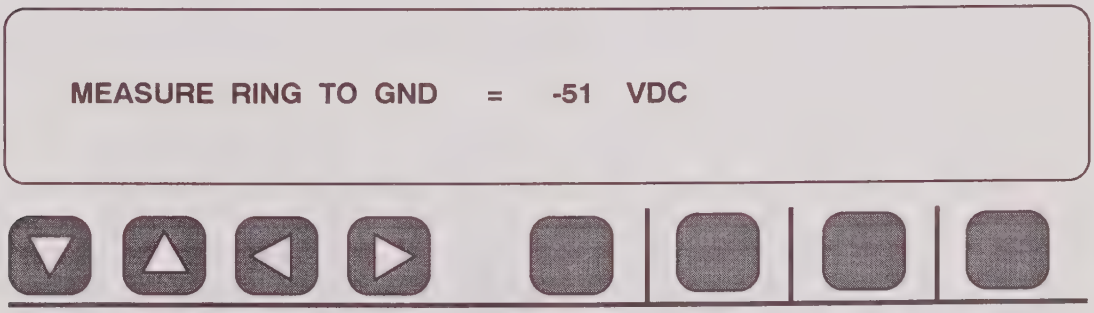


Here a drop of over 5 volts from the ON HOOK level is shown. If no drop had occurred this would indicate an open loop and further checking along the circuit path would be required to determine the source of the open. In order to measure the voltages present from Ring-to-Ground and Tip-to-Ground under ON and OFF HOOK states press any Softkey and the display will scroll

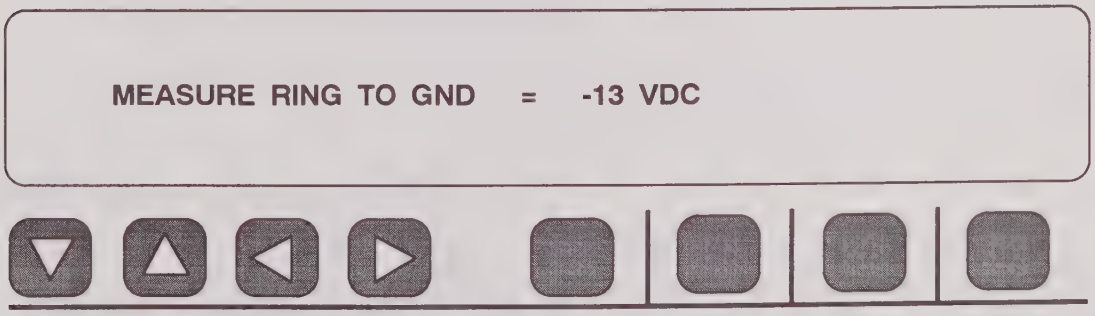
to the next state. For example, if the contact side is ON HOOK and the Ring-to-Tip display is as shown:



Pressing any Softkey will advance the display to the measurement of Ring-to-Ground voltage for the ON HOOK state. An example display follows:

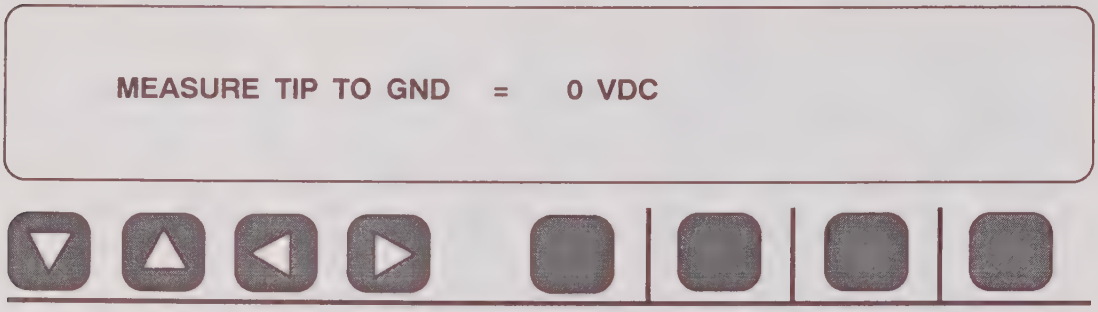


If the contact side goes OFF HOOK then this display would be expected to read as shown below:

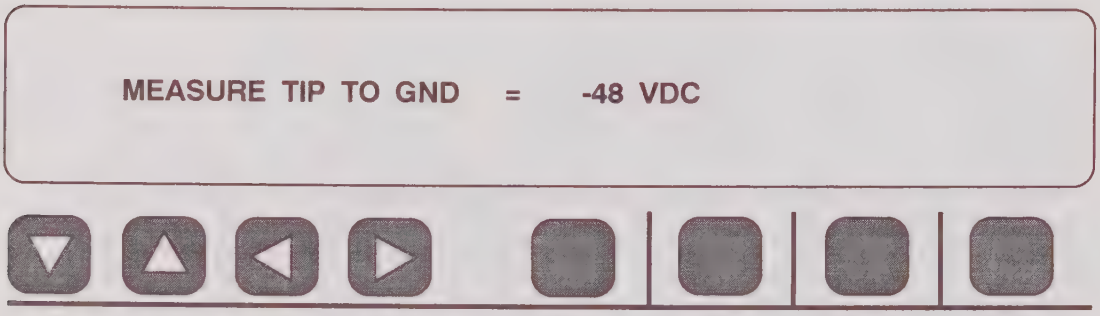


This indicates loop closure or ground on ring. Had this voltage not gone closer to zero then there would have been no loop closure and therefore no trunk seizure after request for service.

Pressing any Softkey in the previous display would advance the 930A to measuring the Tip-to-Ground voltages. An idle state (both sides ON HOOK) should give the following display:



This is the proper indication for a loop start trunk in the idle state. When the battery side goes OFF HOOK, a typical display of Tip-to-Ground voltage would be:



This indicates a battery reversal. Unless these or similar readings were obtained, there would be an indication of trouble in the loop supervision circuitry. Pressing any Function key will exit from this menu option.

The following table lists the range and accuracy for the various 2 Wire and 4 Wire DC Voltage measurements.

	RANGE	ACCURACY
Tip-to-Ring and **TR-to-T1R1:**	+60.0 to -60.0	+/- 1 volt
Tip-to-Ground and **Ring-to-Ground:**	+0.0 to -60.0	+/- 1 volt
TR-to-Ground and **T1R1-to-Ground:**	+0.0 to -60.0	+/- 1 volt
M-to-Ground and **E-to-Ground:**	+0.0 to -100.0	+/- 1 volt

NOTE: Refer to Section 3-12.8 SUPERVISION THRESHOLDS, for a description of the expected voltage levels and 930A supervision.

3-12.8 MENU OPTION NUMBER: 07 SUPERVISION THRESHOLDS

Option Menu: 07 SUPERVISION THRESHOLDS, allows the operator to set the supervision voltage thresholds to nonstandard levels. This enables the 930A front panel supervision lamps to read correctly on non-48V systems, very long subscriber loops, and in other unusual circumstances. Some understanding of trunk supervision circuits is necessary to make use of this feature successfully.

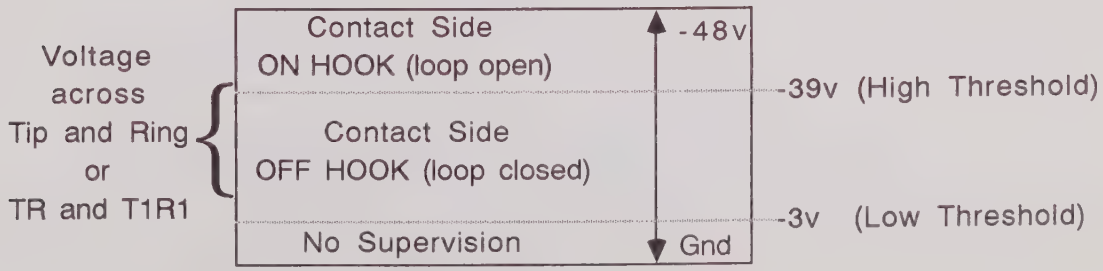
The choices presented to the operator in this menu option will vary, depending upon the current trunk type and which end of the circuit the 930A is on. In all cases however, a series of screens are presented showing a voltage level, a description of the supervision state this represents, and a DEFAULT choice. To change the displayed level, enter a new value using the numeric keypad. To select the factory preset level, press the Softkey labeled "DEFAULT". To accept the currently displayed value, press any other Softkey. Once all the thresholds have been set, the 930A will return to the Option Menu.

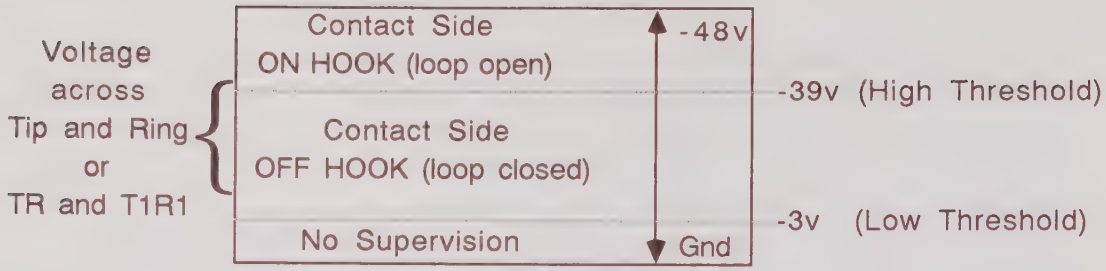
In all cases, "ORIG" refers to the end of the circuit the 930A is on. If the 930A trunk type is LOOP CONTACT for example, **"ORIG OFF HOOK"** means the contact side of the circuit is off hook. If the 930A is providing battery, **"ORIG OFF HOOK"** means the battery side of the circuit is off hook. Voltage levels are printed as absolute values: "< 45V" does **not** mean "more negative than -45 Volts"; it means "less than 45 Volts of potential". Values can be set to the nearest volt with an accuracy of +/- 0.5 VDC. Use Menu Option 06: DC VOLTMETER to examine the current voltage levels.

3-12.8.1 SUPERVISION THRESHOLDS

This section provides a graphic presentation of the various supervision threshold ranges and their corresponding indications.

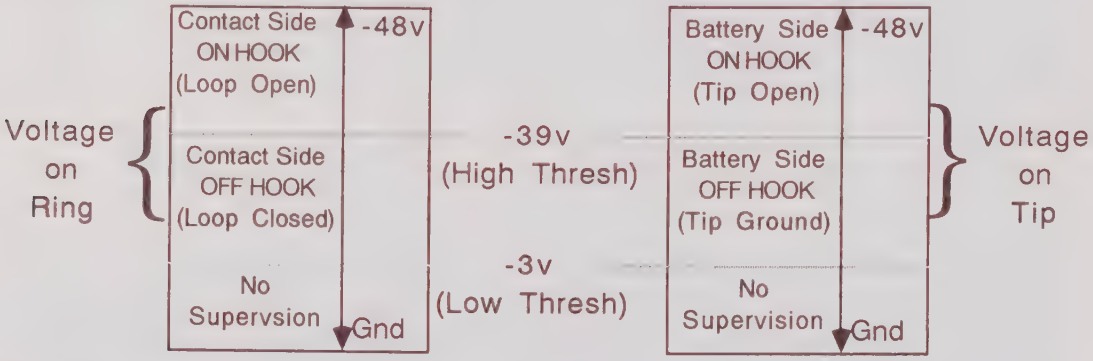
LOOP START SUPERVISION





This shows the ON and OFF HOOK indication states of the supervision LEDs for the default setting of Ring-to-Tip voltage thresholds. Voltages above 39 volts will cause an ON Hook and voltages above 3 and below 39 will cause an OFF Hook. A reversal of -48 Volts and ground would indicate the battery side OFF HOOK.

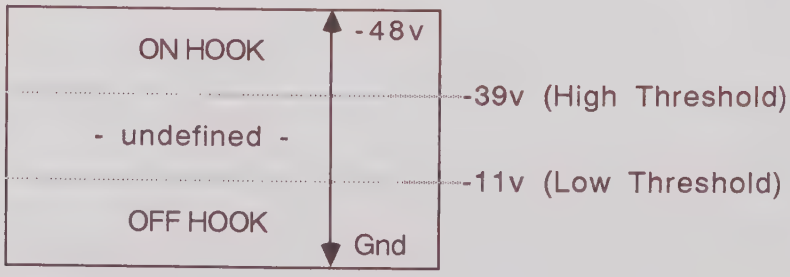
GROUND START SUPERVISION

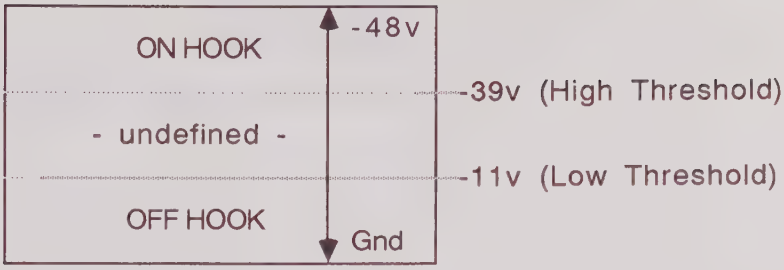


This provides a description of the ON and OFF Hook supervision states at each end of a Ground Start circuit with the default thresholds. Voltages on Ring above 39 Volts indicate ON Hook at the CONTACT side while voltages on Tip in excess of 39 Volts indicate ON Hook on the BATTERY side.

E&M SUPERVISION

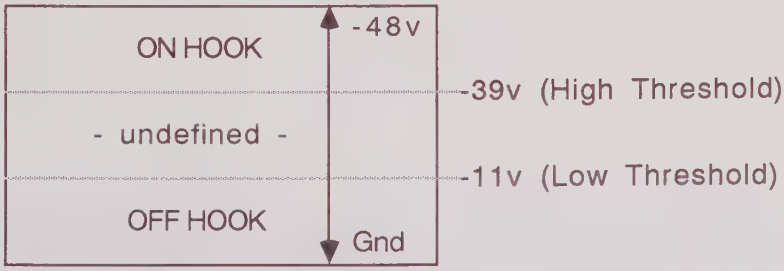
Originating end (SEND-M) indications:





Here, the ORIG LED shows the status of the M-Lead. The TERM LED shows E-Lead status. An OFF HOOK indication is provided if the voltage is below 11 Volts. The LEDs will not be lit for voltages below 39 Volts but above 11 Volts. The LEDs will show an ON HOOK if the voltage is greater than 39 Volts.

Terminating end (SEND-E) indications:



In this case, the ORIG LED shows the status of the E-Lead. The TERM LED shows M-Lead status. The LEDs will not light for voltages below 39 Volts but above 11 Volts. The LEDs will indicate an OFF HOOK if the voltage is below 11 Volts. The LEDs will indicate an ON HOOK for a voltage above 39 Volts.

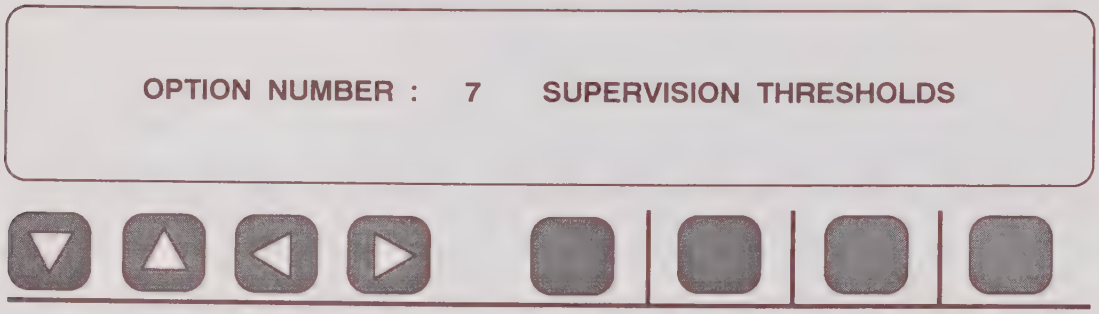
3-12.8.2 LOOP SUPERVISION THRESHOLD EXAMPLE

After setting the 930A to LOOP NORMAL Trunk Type, and simulating a 2 Wire-900 ohm circuit's originating (CONTACT) end as outlined in Section 3-6, perform the following steps to adjust the supervision thresholds.

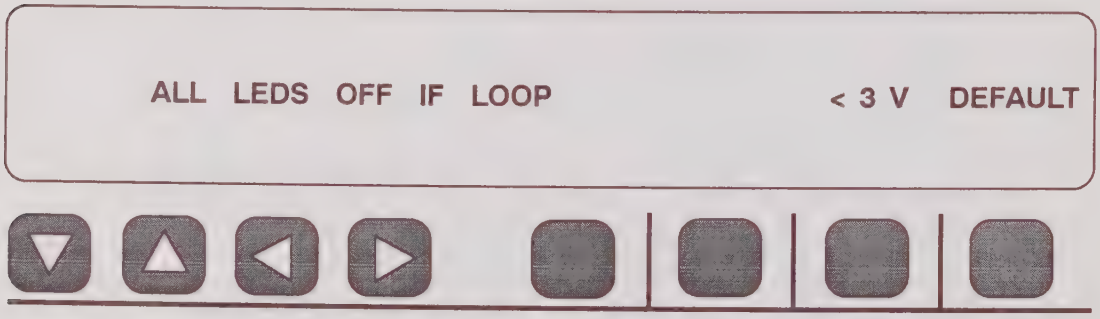
Press the OPTION MENU **Option Menu** function key.

Use the UP/DOWN arrow keys to select Menu Option 07: SUPERVISION THRESHOLDS.

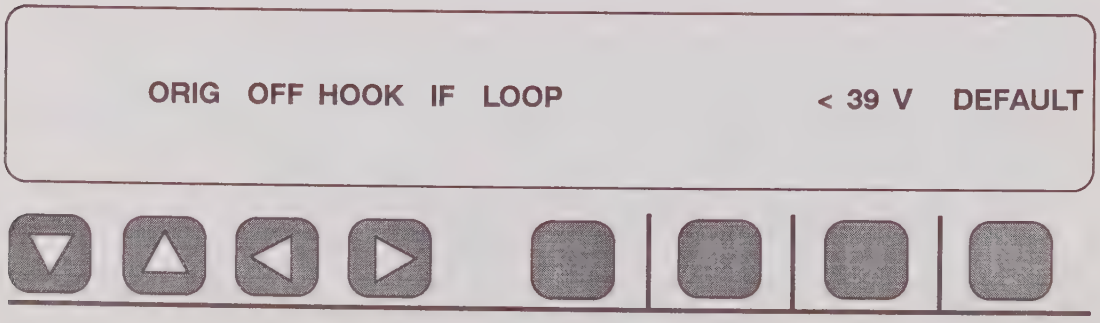
The 930A display will appear as shown below:



Press any Softkey to enter the menu option and the display will appear as:

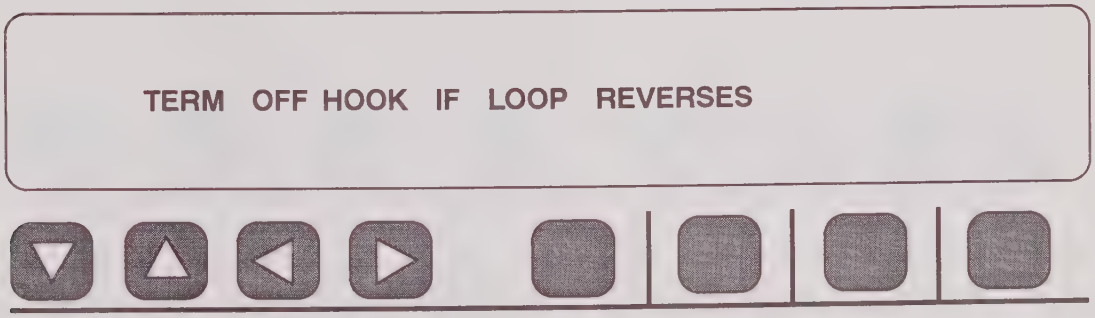


This display means that if there is no talk battery present ("Dry" loop), there will be no voltage across the loop and the 930A will turn off all supervision LEDs. This threshold is preset at 3 Volts. To change this value simply enter the desired value from the numeric keypad and press the ENTER key. Press Softkey 1, 2 or 3 to accept the displayed value and advance the 930A display to:



When the CONTACT side of the circuit goes OFF HOOK, it closes the loop between Tip and Ring (2W) or TR and T1R1 (4W). This lowers the voltage difference across the loop. On a short loop or near the contact end of the circuit, this voltage will be very small. Near the battery (Central Office) end on a long loop, this voltage can remain fairly large. The 930A sees the CONTACT end as being OFF HOOK when the voltage across the loop falls below 39 Volts. However, if a PBX is being tested and it is powered from -24 Volts instead of -48 Volts then the threshold of the 930A should be about 20 Volts. If the PBX is powered from a constant current source, then use the DC Voltmeter (Menu Option 6) to set the voltage threshold empirically.

Press Softkey 4 to choose the default value of 39 Volts or use the numeric keypad to enter the desired value and then press the ENTER key. Press Softkey 1, 2 or 3 to advance the display to:



The above display explains that the 930A expects the BATTERY (Central Office) side of a loop start circuit to provide -48 VDC on Ring (2W) or T1R1 (4W) in NORMAL mode. In LOOP REVERSE, the 930A expects to see -48 VDC on Tip (2W) or TR (4W). The 930A interprets this as the normal ON HOOK condition. A reversal is interpreted as the BATTERY side of the circuit being OFF HOOK. There is no voltage threshold.

In this example, had the 930A been supplying BATTERY instead of CONTACT the displays would have been slightly different but the principle would have been the same. Essentially, Menu Option 7 enables the operator to adjust the supervision voltages so the front panel LED supervision indicators will read properly under unusual circumstances and the 930A will receive and analyze digits under those conditions.

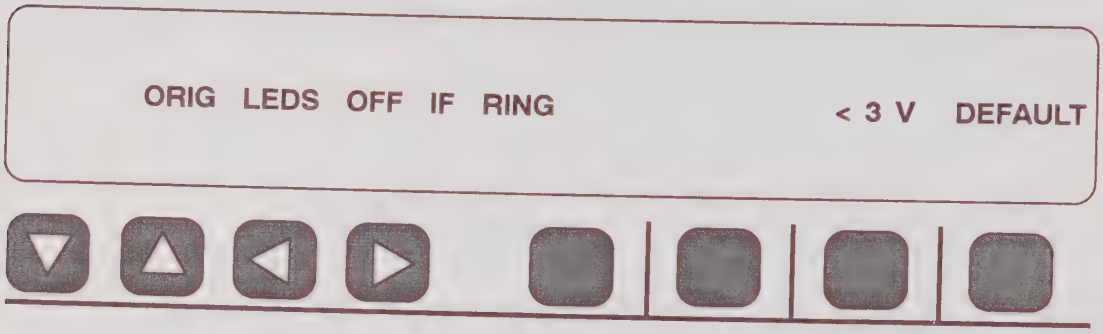
IT DOES NOT MEAN THAT THE 930A WILL OUTPUT OTHER THAN -48 VDC SUPERVISION, MERELY THAT IT WILL RECOGNIZE OTHER VOLTAGES AT ITS INPUT.

3-12.8.3 GROUND START SUPERVISION EXAMPLE

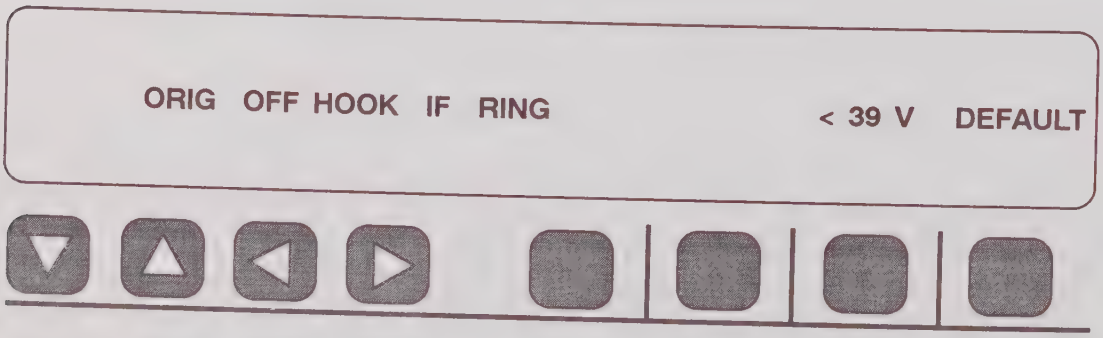
In the following discussion, a 2 Wire 900 ohm, NORMAL Ground Start trunk type is assumed for the 930A. Further assume that the 930A is in CONTACT mode.

The following describes normal 2 Wire trunks. For REVERSE circuits, Tip and Ring are interchanged. On 4 Wire circuits, TR replaces Tip and T1R1 replaces Ring.

After selecting Menu Option 7 and pressing a Softkey to enter the menu as previously described in Section 3-12.8.1, the 930A display will be:

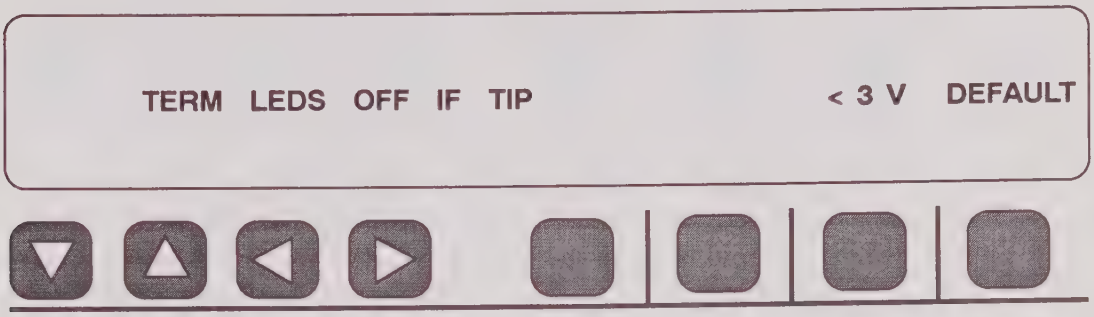


As before, this display explains that if there is no talk battery detected, there will be no voltage on Ring and the 930A will turn off the supervision LEDs on the contact side. The preset voltage threshold is 3 Volts. To change this value simply enter the desired number from the numeric keypad and press the ENTER key. Press Softkey 4 to choose the default value. Press Softkey 1, 2 or 3 to advance the display to:

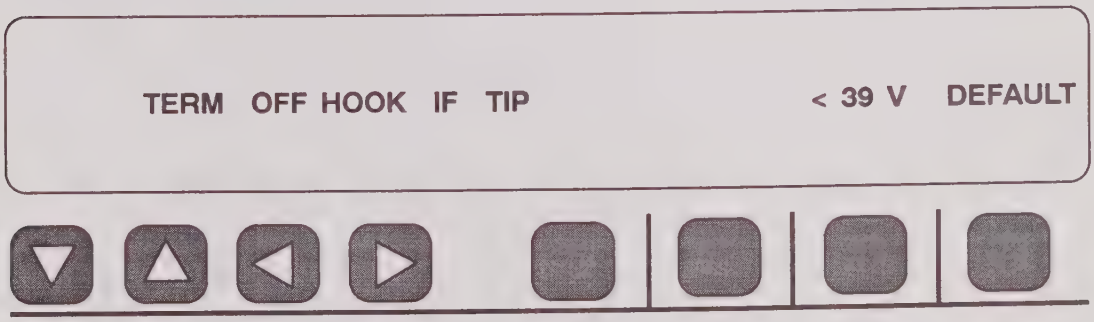


When the contact side goes OFF HOOK, it places ground on Ring or provides loop after the battery side has grounded Tip. In either case the voltage on

Ring goes toward ground. The preset default threshold is 39 Volts as shown above. If the circuit is a -24 Volt system, the threshold should probably be set to about 20 Volts. Enter 2 and 0 and press ENTER. Press Softkey 1, 2, or 3 and the screen will advance to:



If there is no high impedance supervision battery on Tip, or a loop condition exists and there is no talk battery on Ring, there will be no voltage present on Tip and the 930A will turn off the supervision LEDs on the battery side. The factory set default is 3 Volts as shown above. The value may be changed by entering the desired value from the numeric keypad and then pressing the ENTER key. Press Softkey 1, 2 or 3 and the 930A display will advance to:

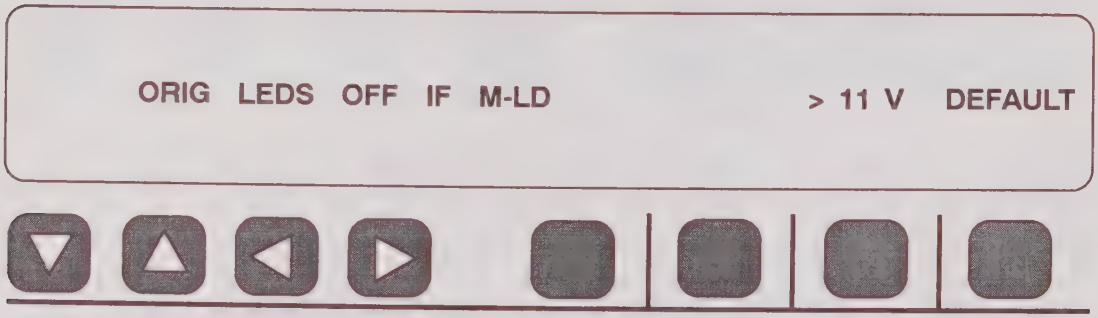


When the battery side goes OFF HOOK or connects a digit receiver, it grounds Tip and the voltage on Tip goes toward ground. The default threshold is 39 Volts as shown above. To change this value simply enter the desired number from the numeric keypad and then press ENTER.

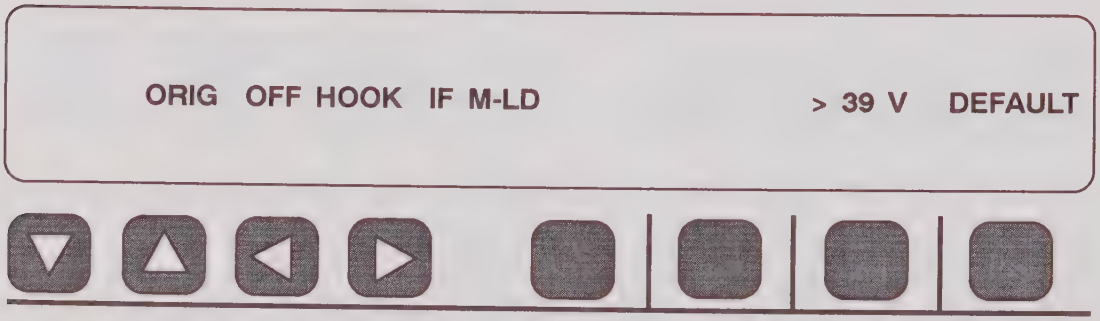
3-12.8.4 E&M SUPERVISION THRESHOLD EXAMPLE

The various E&M Types (1 through 5) have different means of providing supervision battery to the E and M leads but the end result is the same. In one supervision state the lead is held at -48 Volts. In the other state it is held close to ground. The intermediate voltages are interpreted as "no indication" and the 930A turns off the appropriate LEDs.

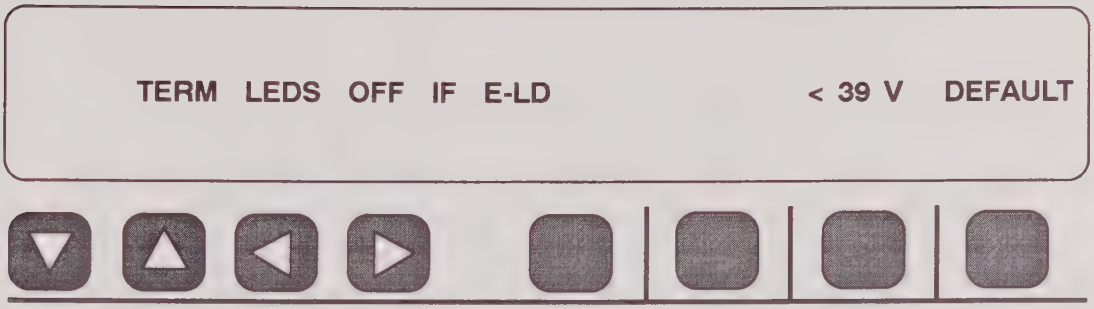
For example purposes, a 930A set to E&M Type I, SEND-M operation is assumed. Upon entering Menu Option 7 the 930A display will be:



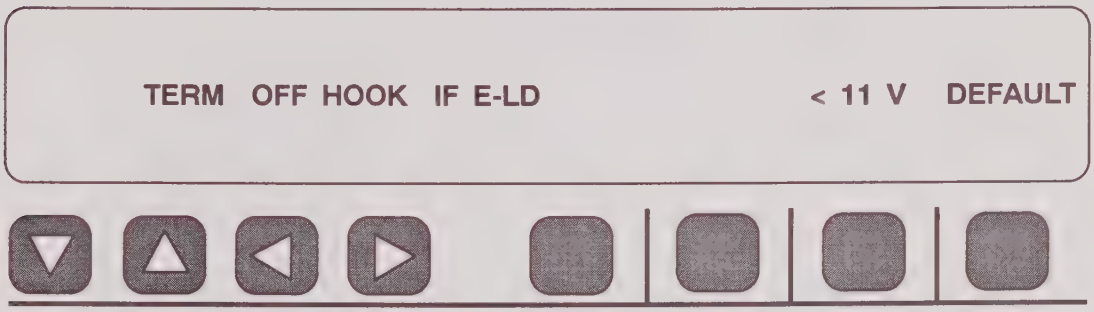
The 930A will turn off the originating supervision LEDs if the M-Lead voltage is greater than 11 Volts but less than the OFF HOOK threshold. The default threshold displayed above may be changed by entering a new number from the numeric keypad and pressing the ENTER key. Pressing Softkeys 1, 2, or 3 in the above display would choose the displayed value and advance the display to:



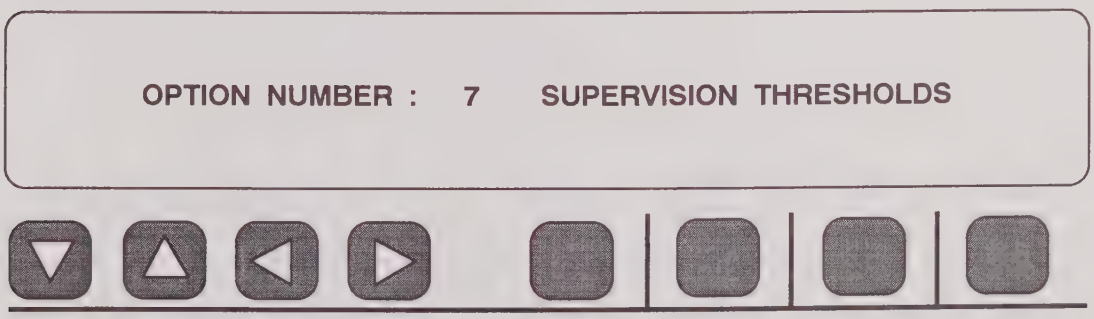
In this case the 930A will provide an OFF HOOK indication on the Originating LEDs if the voltage on the M-Lead exceeds the 39 Volt threshold. The threshold can be changed as previously described or, the default value may be kept by pressing any softkey to advance the display to:



Here the 930A will provide no supervision indication if the voltage on the E-Lead is below the high threshold of 39 Volts but above the low threshold of 11 Volts. The high threshold can be changed or accepted as before and the 930A display will advance to:



An Off Hook indication on the front panel LEDs will be provided if the voltage on the E-Lead is below the 11 Volt low threshold. This value can either be changed or accepted and the 930A will return to the Option Menu display repeated below:



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3-12.9 MENU OPTION NUMBER: 8 SUPERVISION MONITOR

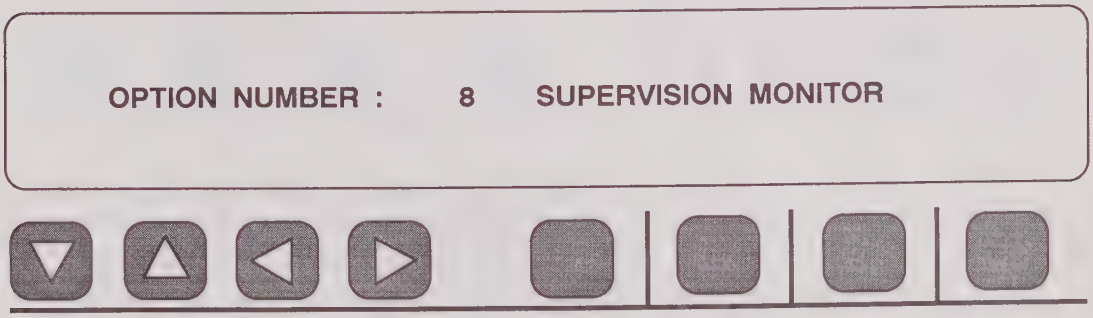
Menu Option 8: SUPERVISION MONITOR gives the Model 930A the equivalent of a "strip chart recorder" function for timing events of long duration as well as for timing supervision events such as guard times, ground start timing and other events not covered by Menu Option 9: WINK TIMING.

In order to use this menu option, it must first be set up in the following manner:

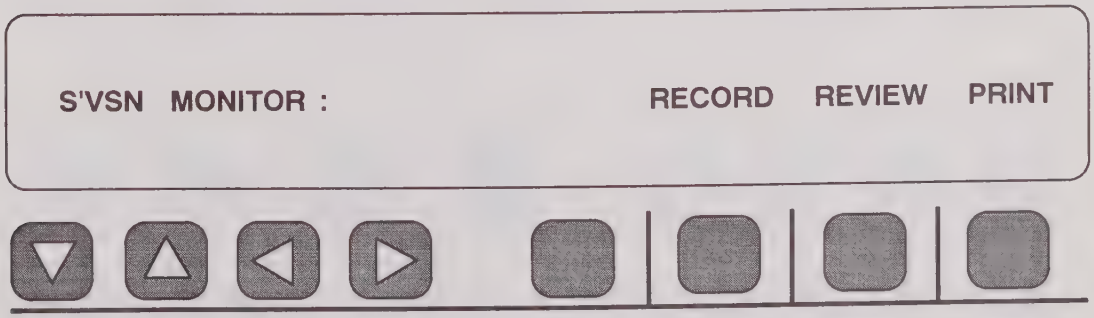
Press the OPTION MENU **Option Menu** function key.

Use the UP/DOWN arrow keys to select Menu Option 08: SUPERVISION MONITOR.

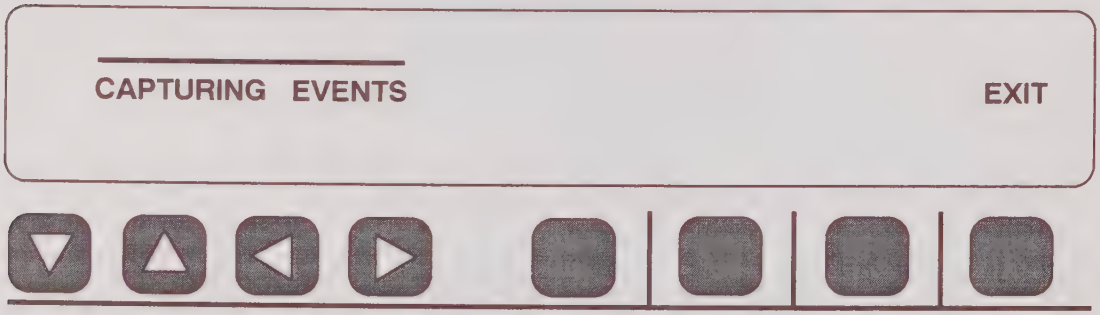
The display will appear as shown below:



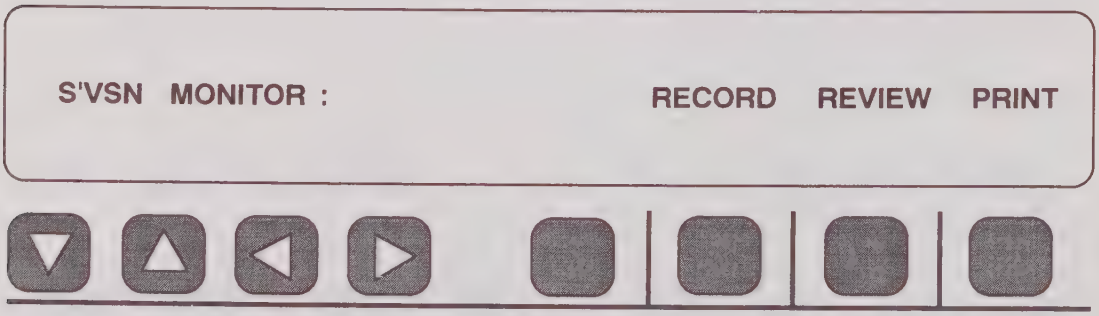
The main menu is accessed by pressing any Softkey and appears as:



To record events in a time line format, press Softkey 2 labeled RECORD and the 930A will act very much like a strip chart recorder and will record supervision events such as On Hooks and Off Hooks. Just as with a strip chart recorder however, it is up to the operator to determine what is going on over time. After pressing Softkey 2 the 930A display will appear as:

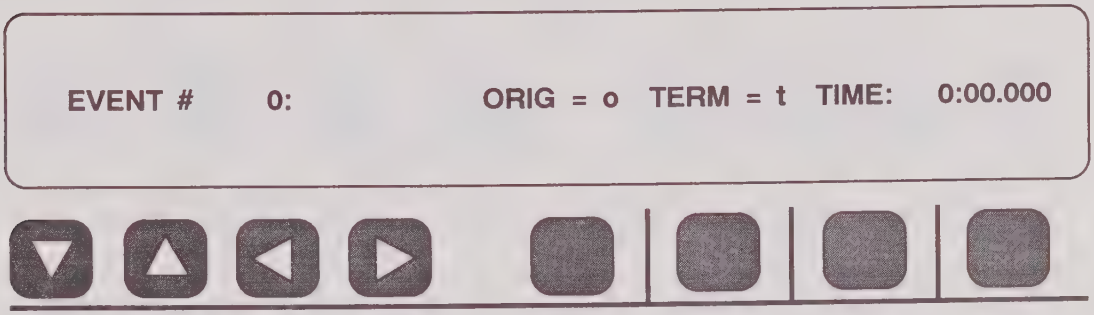


The cursor flashes over the words "Capturing Events". When the operator feels that enough data has been obtained, a press of Softkey 4 labeled EXIT will return the 930A to the main menu and stop the data acquisition. The main menu is repeated below:

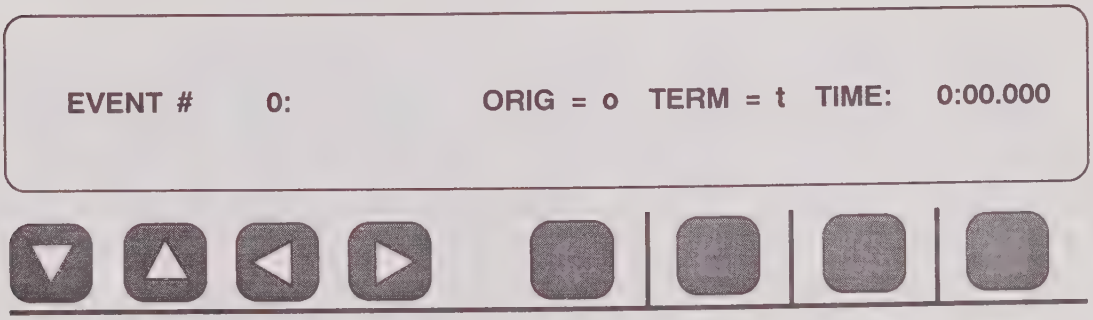


The events captured in the RECORD mode may now be reviewed by pressing Softkey 3 labeled REVIEW. The display of the events varies according to the

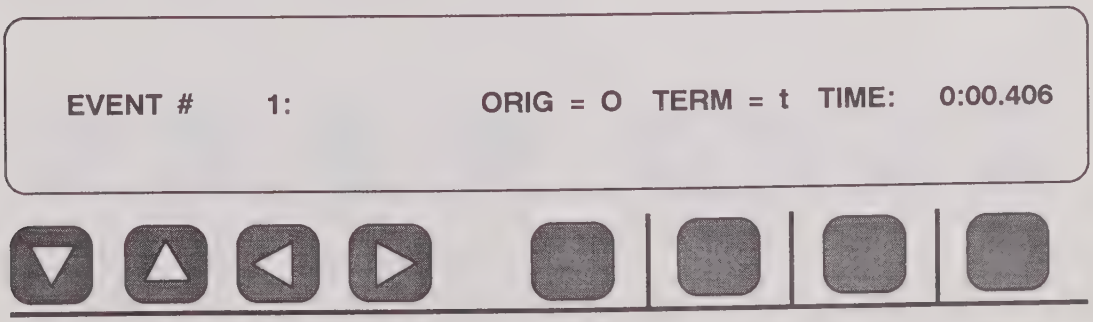
trunk type the 930A is set up to emulate. For example, if the 930A had been timing events on a metallic trunk such as a Loop Start or Ground Start trunk, the results would be displayed as shown in the example below:

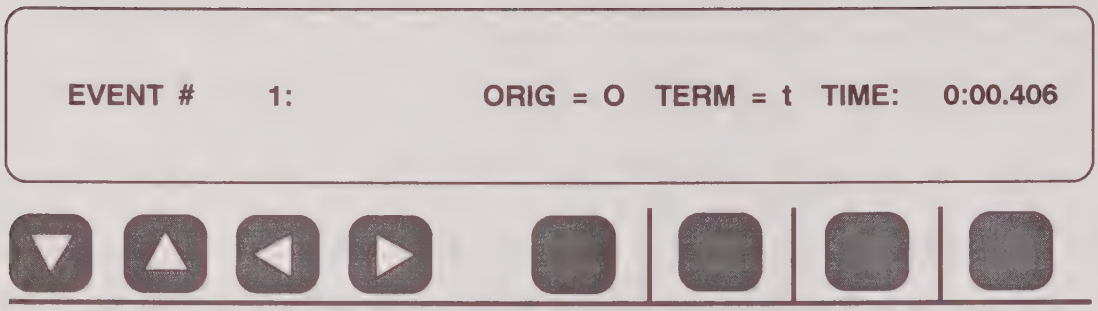


The display follows the front panel supervision LEDs. In this case both the Originate and Terminate sides of the circuit are On Hook as indicated by the lower case letters "o" and "t". The time is displayed as minutes: seconds.milliseconds up to 255:59.999. An example of a sequence of events will demonstrate how this works in practice. Suppose the 930A had been capturing events for a period of time. After stopping the data collection as described above, assume the first displayed result is:



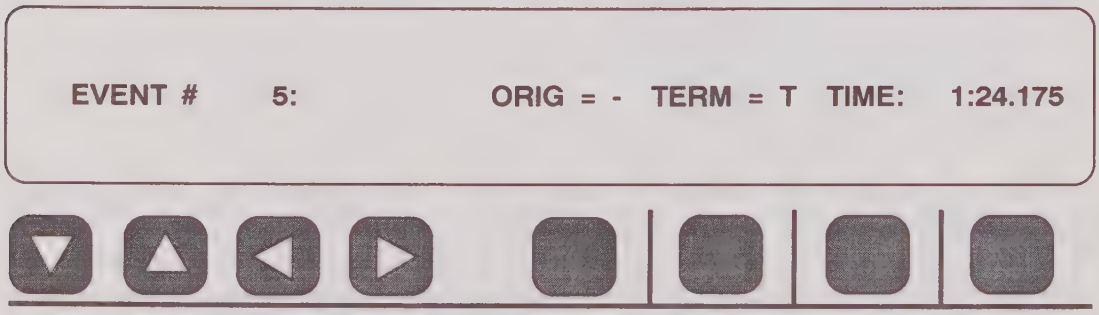
By pressing the UP arrow key or Softkey 1 the operator can scroll up through the rest of the results. The next event might, for example, be:



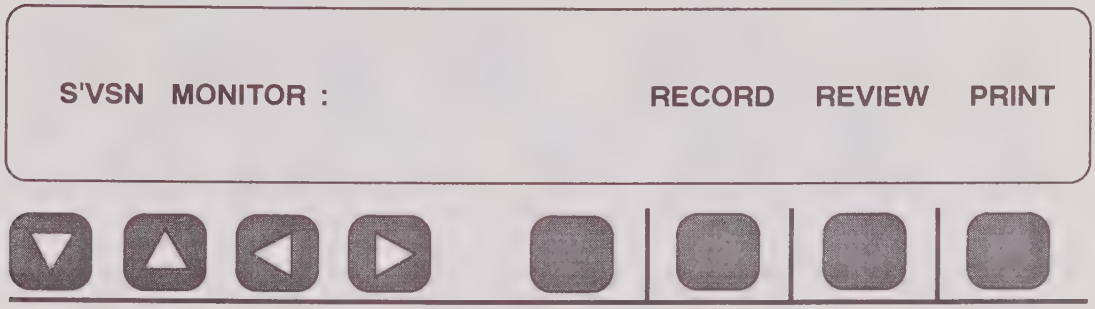


Here the Originating end has gone Off Hook after 406 milliseconds. The display of event #2 might be:

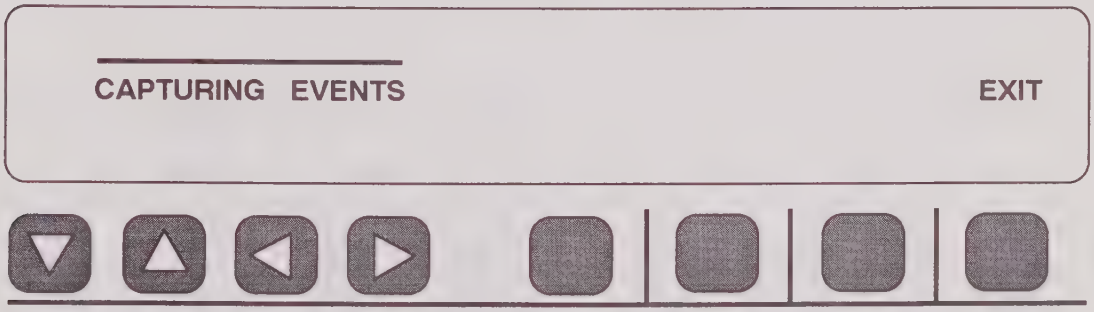
The Terminate end has gone Off Hook after 1.636 seconds. The 930A can time up to 400 events or for up to 4 hours. If the supervision on the line enters an undefined state (neither On Hook nor Off Hook), the 930A will display it as undefined by showing a dash "-" instead of an upper or lower case character. Only supervision events are shown. Tones, digits and speech are not captured by the supervision monitor. An example display is shown below:



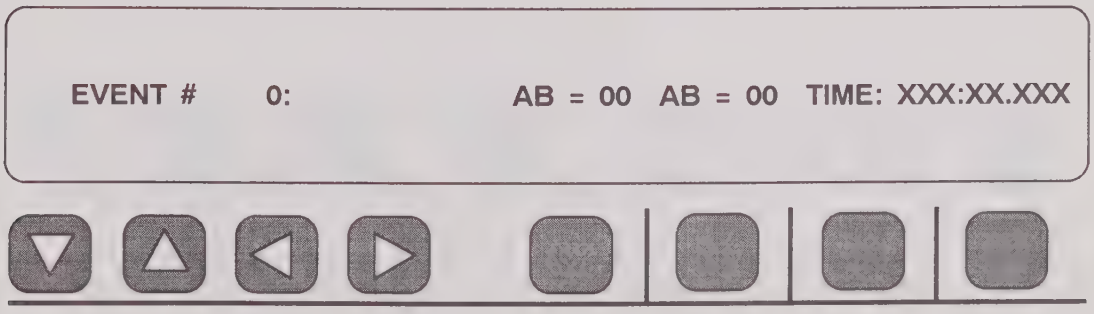
If the operator has a 930A equipped with option 930A-08 or 930A-09, then events on T-1 PCM trunks can also be timed. The procedure is much the same as with metallic trunks. Begin by setting the 930A to capture event times by pressing the softkey labeled RECORD as shown below:

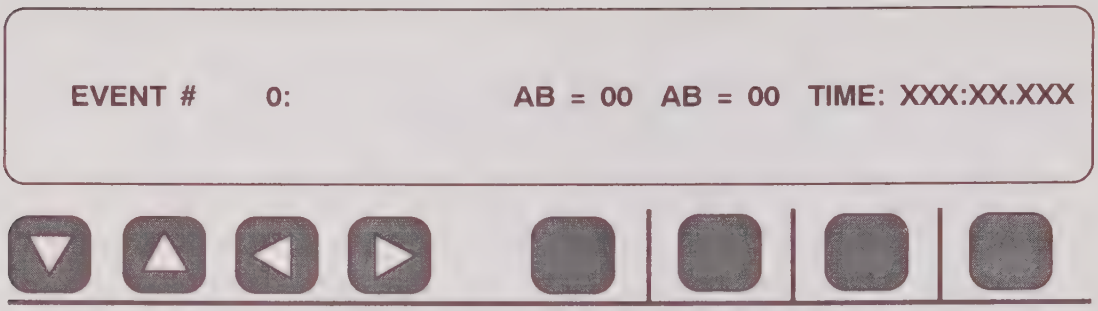


The 930A will indicate that it is capturing events by presenting the following display:



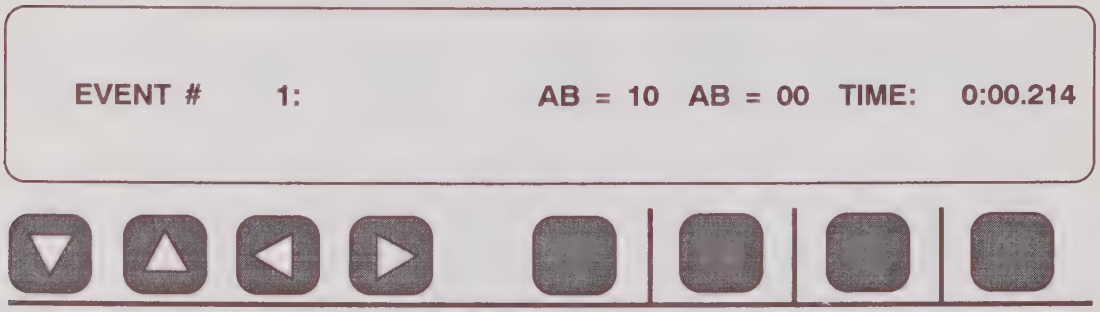
After enough time has gone by to assure that the desired information has been recorded, pressing softkey 4 will exit back to the main menu and stop the event timing. The difference is that on a PCM trunk, all supervision events are in terms of the states of the "A" and "B" bits and it is these states which are displayed. A typical display of event timing on a PCM trunk would look like:



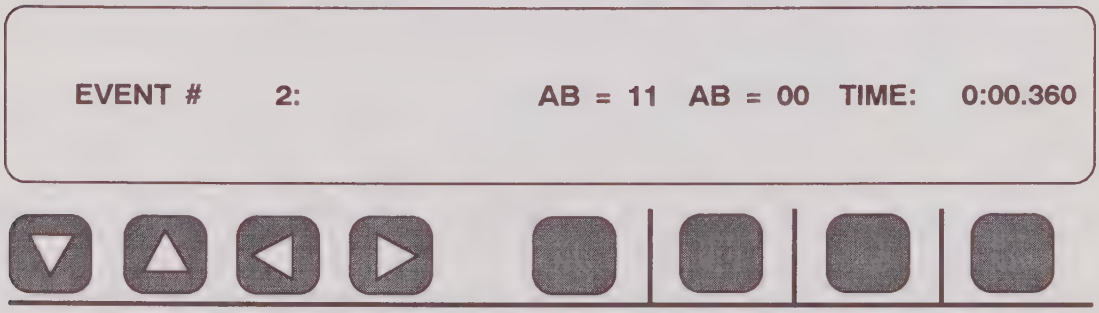


In this display, the originating end's A and B bits are on the left and the terminating end's are on the right. The time is displayed as it was for the metallic trunks. The A and B bit states may vary for On and Off Hook indications depending upon whether a normal trunk or an FX trunk is accessed.

Some typical displays follow:

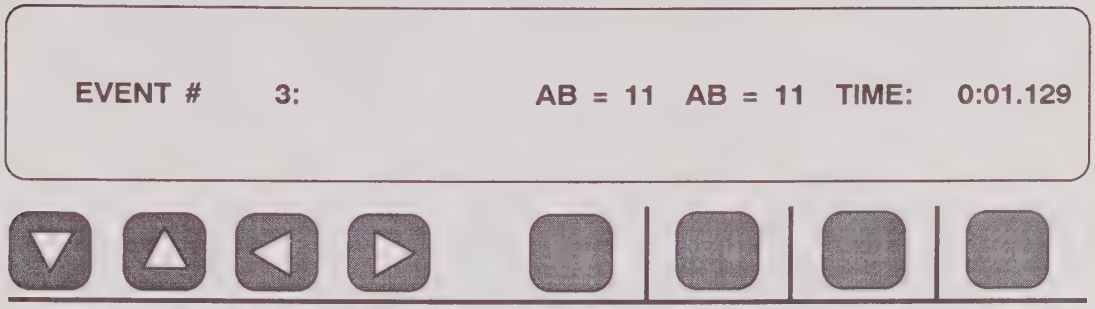


This indicates that the originate A bit went high after 214 milliseconds. Pressing the UP arrow key would bring up event #2.



Here, the originate B bit went high 146 milliseconds after event #1 or 360 milliseconds into the measurement.

Pressing the UP arrow key again brings up:



This shows that the next event was the terminate end's A and B bits going high after 1.129 seconds had elapsed.

Needless to say these are just examples of displays and are not meant to convey any sense of real events. They merely illustrate the operation of the Supervision Monitor function on metallic or PCM trunks.

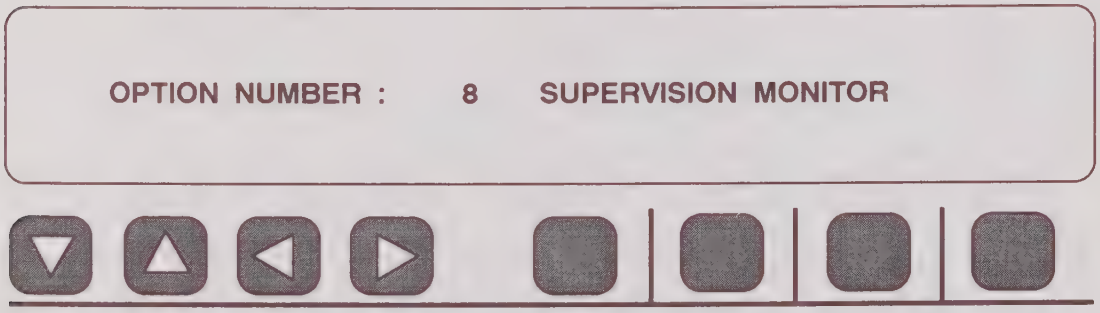
This function will enable the user to measure guard intervals, times between the last digit dialed and an Off Hook indication, and the time between a request for service and the response back to name a few. It can also be used on services such as Enhanced 911 to measure the call completion time which in the case of E911 must be less than 3 seconds.

Finally, this function provides the user with the ability to print out the results on a demand basis as opposed to using the PRINT function contained under option 930A-10C. If the PRINT function under option 930A-10C is enabled then everything will be printed out as it occurs. However, to prevent running off reams of paper full of useless data, the Supervision Monitor function provides the user with a PRINT key (Softkey 4 in the main menu) so that after the results of the measurements have been reviewed to be sure that they are the desired results then they can be printed out on demand. Of course, this still requires that the 930A has option 930A-10C installed to provide the RS-232 interface to a serial printer but now the operator has control over what gets printed and when.

To obtain a printout from the 930A return to the main menu as shown:

Press Softkey 4 labeled PRINT and the 930A will print out the results of the event timing.

To exit from the Supervision Monitor and return to the main menu option list, press the OPTION MENU function key or any other function key and the display will become:



At this point the operator can go to any other menu or function.

3-12.10 MENU OPTION NUMBER: 31 SEND HOOK FLASH

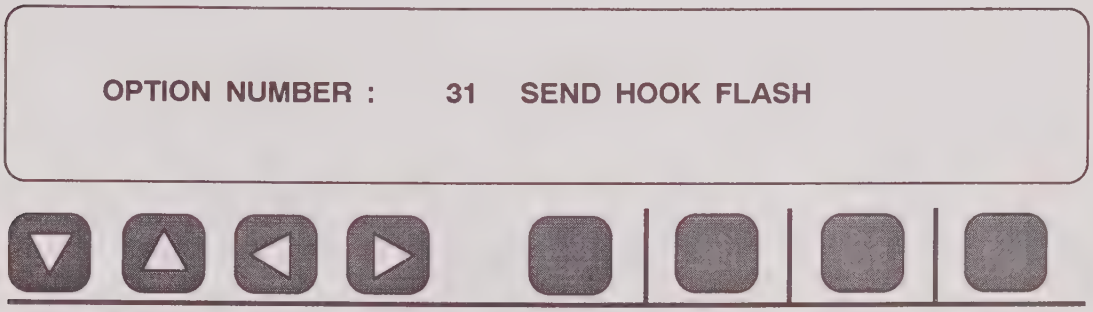
Menu Option 31: SEND HOOK FLASH enables the operator to send a Hook Flash from the 930A. The length of the Hook Flash is nominally 200 milliseconds but is variable from 10 to 9999 milliseconds. This feature allows the operator to check out a switch or PBX flash recognition capability.

To use this feature, perform the following steps:

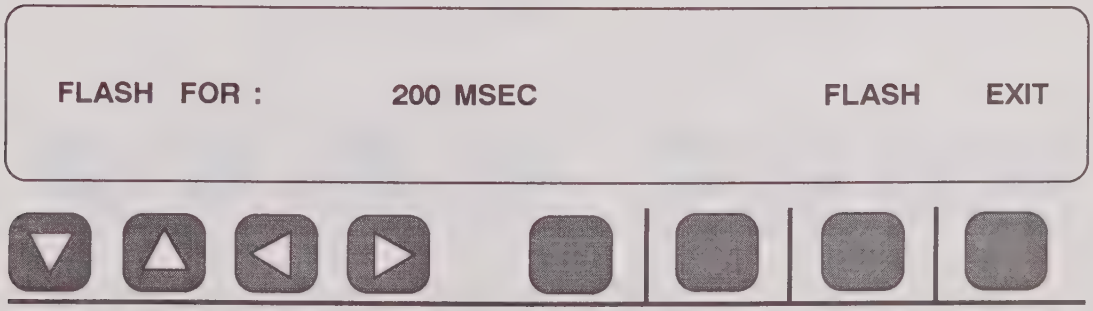
Press the OPTION MENU Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 31: SEND FLASH HOOK.

The display will appear as shown below:



Pressing any Softkey will bring up the main menu which is shown below:



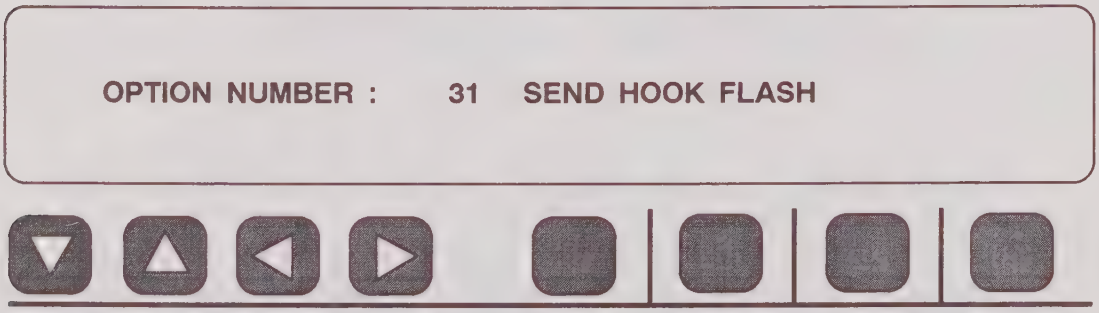
The length of the Hook Flash may be varied to any desired interval between 10 milliseconds and 9999 milliseconds. Bear in mind that very short

duration flashes (< 50 msecs.) will not be indicated by the front panel supervision LEDs. To set in a different duration flash hook, simply enter the desired number using the numeric keypad and then press the ENTer key.

To send a flash hook of the displayed duration, press Softkey 3 labeled FLASH. Using the display shown below:

pressing Softkey 3 would cause a 200 millisecond flash hook to be sent from the 930A on the metallic trunk or PCM channel (if Option 930A-08 or -09 is installed) selected. If the 930A is on hook, pressing the FLASH softkey causes it to go off hook for the prescribed number of milliseconds. If the 930A is off hook, pressing the FLASH softkey causes the 930A to go on hook during the flash.

To exit from this menu option press Softkey 4 labeled EXIT in the above display or press the OPTION MENU function key and the display will return to:



SECTION IV
OPTIONS

4-1 INTRODUCTION

The Model 930A may be equipped with a number of optional features which expand and enhance its test and measurement capabilities. This section describes the operation of the Model 930A when equipped with these available options.

The following lists the currently available options for the Model 930A:

OPTION	DESCRIPTION	SECTION
930A-01	MF/DTMF/DP Receiver and Analyzer	4-2
930A-02	SF Supervision	4-3
930A-06	P/AR Measurement	4-4
930A-07	3-Level Impulse Noise	4-5
930A-08	Single Direction DS-1 PCM Access	4-6
930A-09	Dual Direction DS-1 Drop and Insert	4-6
930A-10C	RS-232C Remote Control/Printer Interface with Real Time Clock (Covered in Section V).	See Sect. 5
930A-12	ROTL/Near End Responder/Far End Responder (Type 105 Compatible) (Requires Option 930A-01).	4-7
930A-13	Ring Generator/REN-3 Load	4-9
930A-14	LTTP/STTP (1/1A ESS) Interface	N/A
930A-15	Blank Front Panel (Rear Panel Access)	N/A
930A-16	-48 VDC Power Supply	N/A
930A-17	Removes 2W/4W Metallic Interface (Requires Option 930A-08 or -09)	N/A
930A-18	Phase Jitter/Hits (Requires Option 930A-07)	4-11
930A-19	Envelope Delay Distortion	4-12
930A-20	4-Tone Intermodulation Distortion*	4-10
930A-24	DACS Interface with Remote Audio (Requires Options 930A-01, 09, 10C, -17)	4-13
930A-25	FXO/FXS Supervision (Requires Option 930A-08 or -09)	4-6.2.2
930A-26	Remote Audio (Requires Option 930A-10C)	4-8

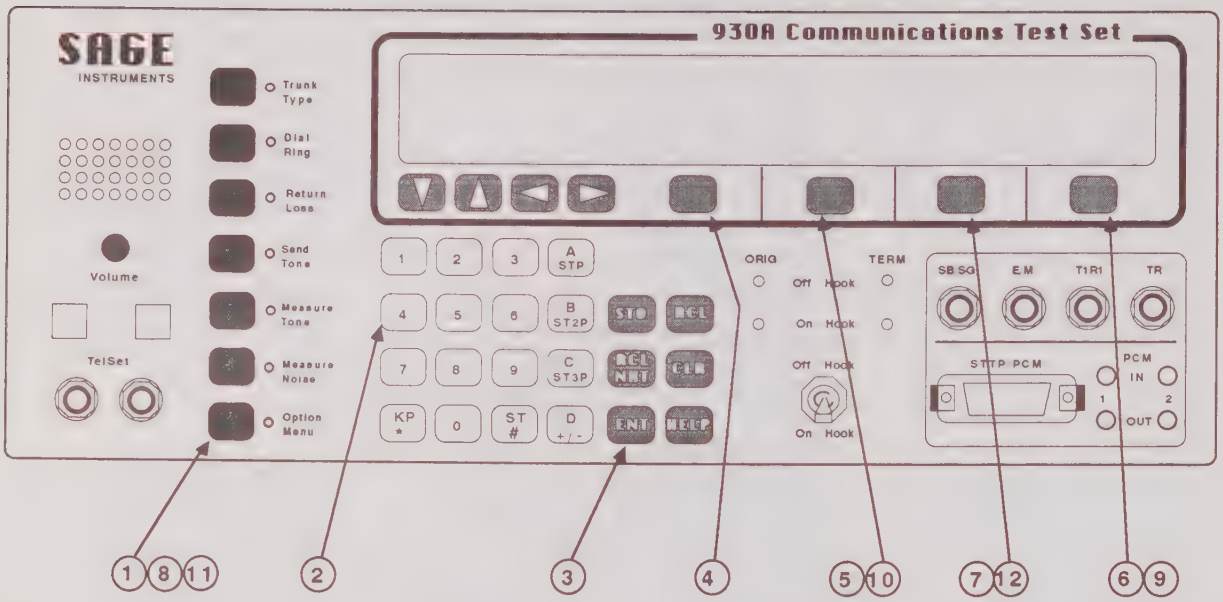
* Licensed under Hekimian Laboratories Patent No. 3,862,380

This section is organized by option number and proceeds in order from Option 930A-01. The exceptions to this rule are Option 930A-10C which is described in Section V, REMOTE CONTROL OPERATION, and Options 930A-15, -16 and -17 which are self explanatory.

To prevent possible confusion between purchased option numbers and the Option Menu numbers, Table 4-1 provides a cross reference.

TABLE 4-1
MENU OPTION NUMBERS

MENU OPTION NUMBER	DESCRIPTION	PURCHASED OPTION
OPTION NUMBER: 1	MODIFY DIAL/RING	STANDARD
OPTION NUMBER: 2	SEND DIGIT SEQUENCES	STANDARD
OPTION NUMBER: 3	REMOTE CONTROL	OPTION 930A-10C
OPTION NUMBER: 4	DIGIT RECEIVER	OPTION 930A-01
OPTION NUMBER: 5	REN-3 LOAD	OPTION 930A-13
OPTION NUMBER: 6	D.C. VOLTMETER	STANDARD
OPTION NUMBER: 7	SUPERVISION THRESHOLDS	STANDARD
OPTION NUMBER: 8	SUPERVISION MONITOR	STANDARD
OPTION NUMBER: 9	WINK TIMING	STANDARD
OPTION NUMBER: 10	FREQUENCY SWEEP	STANDARD
OPTION NUMBER: 11	3-LEVEL IMPULSE NOISE	OPTION 930A-07
OPTION NUMBER: 12	WINK MARGINING	OPTION 930A-01
OPTION NUMBER: 13	PHASE/AMPLITUDE JITTER	OPTION 930A-18
OPTION NUMBER: 14	SET TIME AND DATE	OPTION 930A-10C
OPTION NUMBER: 15	BEEP ON ERROR	STANDARD
OPTION NUMBER: 16	REMOTE AUDIO MONITOR	OPTION 930A-26
OPTION NUMBER: 17	ENVELOPE DELAY DISTORTION	OPTION 930A-19
OPTION NUMBER: 18	PEAK/AVERAGE RATIO	OPTION 930A-06
OPTION NUMBER: 19	4-TONE INTERMODULATION	OPTION 930A-20
OPTION NUMBER: 20	24 BIT DISPLAY	OPTION 930A-08 OPTION 930A-09
OPTION NUMBER: 21	TOGGLE A/B BITS	OPTION 930A-08 OPTION 930A-09
OPTION NUMBER: 22	RESERVED	
OPTION NUMBER: 23	RESERVED	
OPTION NUMBER: 24	RESERVED	
OPTION NUMBER: 25	FAR END RESPONDER	OPTION 930A-12
OPTION NUMBER: 26	ROTL/NEAR END RESPONDER	OPTION 930A-12
OPTION NUMBER: 27	ROTL INTERROGATOR	OPTION 930A-12
OPTION NUMBER: 28	RESERVED	
OPTION NUMBER: 29	RESERVED	
OPTION NUMBER: 30	ADJUST TLP	STANDARD
OPTION NUMBER: 31	SEND HOOK FLASH	STANDARD
OPTION NUMBER: 32	DIAL-UP TESTLINE	STANDARD
OPTION NUMBERS 33 TO 98	RESERVED FOR FUTURE EXPANSION	



To Receive and Analyze MF, DTMF, or DP Sequences:

1. Press the OPTION MENU function key.
2. Press the number 4.
3. Press the ENT (Enter) key to initiate Menu Option 4 DIGIT RECEIVER.
4. Press Softkey 1 to select the SET-UP menu.
5. Press Softkey 2 to set the Receive Parameters.
6. Press Softkey 4 to Exit back to the SET-UP menu.
7. Press Softkey 3 to set the Receive Sequence.
8. Press the OPTION MENU function key to return to the SET-UP menu.
9. Press Softkey 4 to Exit back to the main Receiver menu.
10. Press Softkey 2 to receive records.
11. When records have been received, press the OPTION MENU function key to return to the main menu.
12. Press Softkey 3 to Analyze Records.

THE DIGIT RECEIVER/ANALYZER
FIGURE 4-1

4-2 RECEIVE RECORDS (OPT. 930A-01 DP/MF/DTMF RECEIVER)

The Digit Receiver option is composed of 2 menu options which are installed in the Model 930A when Option 930A-01: DP/MF/DTMF RECEIVER/ANALYZER has been ordered. These menu options appear under the OPTION MENU key as:

1) OPTION NUMBER: 4 DIGIT RECEIVER
2) OPTION NUMBER: 12 WINK MARGINING

The Digit Receiver option can be used in BRIDGE mode to monitor the interaction between equipment, or in the TERM mode, which enables the 930A to completely simulate terminating equipment. In either case the 930A will record the outpulsed digits it receives. In the TERM mode the 930A will supply supervision. In the BRIDGE mode, it will look for and time supervision events (Winks, Off-Hooks, etc.). The 930A breaks an outpulsing sequence into groups of digits and supervision events. The digit groups, which can be MF, DTMF, or DP sequences, are called Records. The supervision events are divided into Winks, Delays, and Off-Hooks. The following sub-sections provide a detailed description of the use and operation of each of the two Menu Options which comprise the Digit Receiver group.

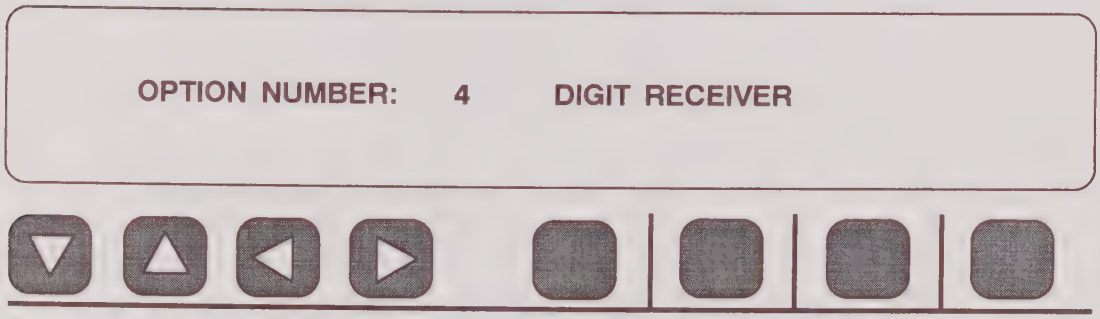
4-2.1 MENU OPTION NUMBER: 4 DIGIT RECEIVER

The length, type, and sequence of each record to be received as well as the choice between receiving and analyzing what has been received is set in Menu Option 04. A string of 10 DTMF digits would be one record for example. This menu option allows the operator to tell the 930A what to expect in the way of length, type and sequence of records. The user must set up the appropriate parameters in this menu option, BEFORE attempting to receive single or multiple records, by performing the following steps:

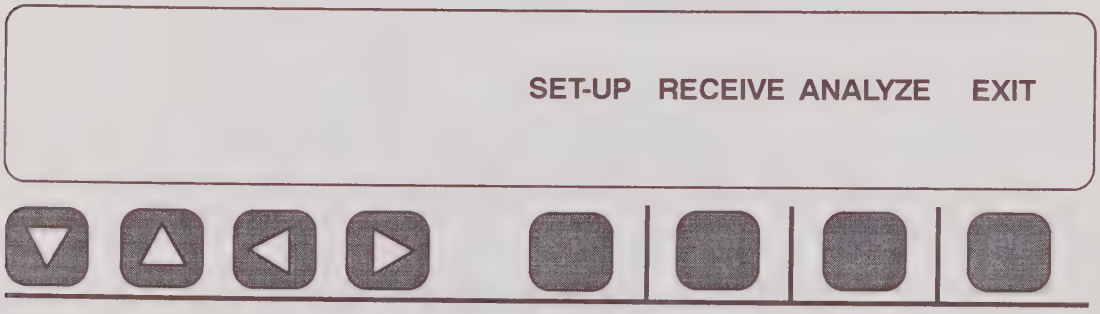
Press the OPTION MENU function key.

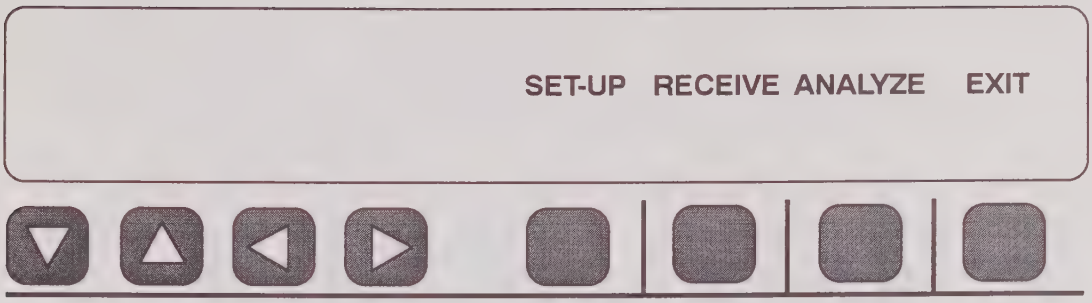
Use the UP/DOWN arrow keys to select Menu Option 04: DIGIT RECEIVER.

The 930A display is shown below:



Press any Softkey to enter the menu option. The primary digit receiver menu is shown below:





The functions of the front panel keys within this menu option display are as follows:

Pressing Softkey 1 (labeled "SET-UP") will enter the set-up menu for the receiver.

Pressing Softkey 2 (labeled "RECEIVE") will activate the digit receiver.

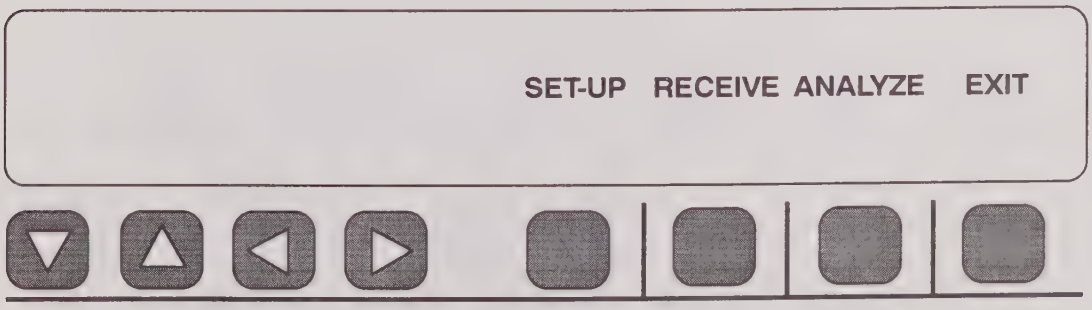
Pressing Softkey 3 (labeled "ANALYZE") will enter the digit analyzer.

Pressing Softkey 4 (labeled "EXIT") will exit back to the Option Menu display.

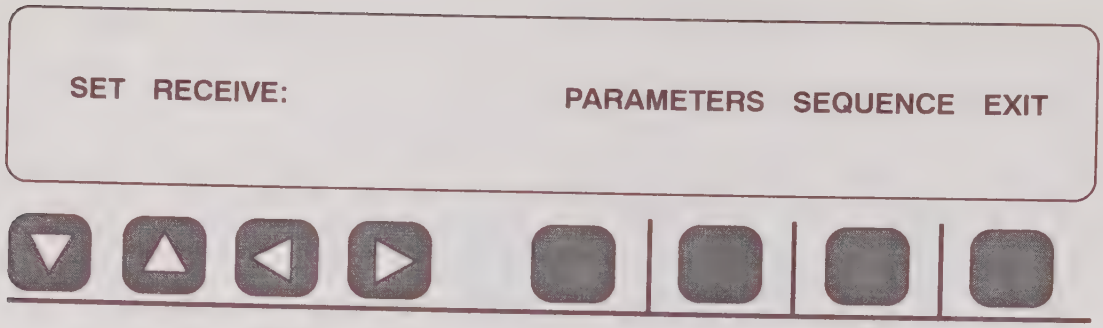
Pressing any Function key (i.e., DIAL/RING, SEND TONE, etc.) will also cause the 930A to exit to the appropriate function.

The following steps illustrate how to initially set up the 930A to receive and analyze single or multiple record sequences.

After entering Menu Option 4 the 930A display appears as previously shown:

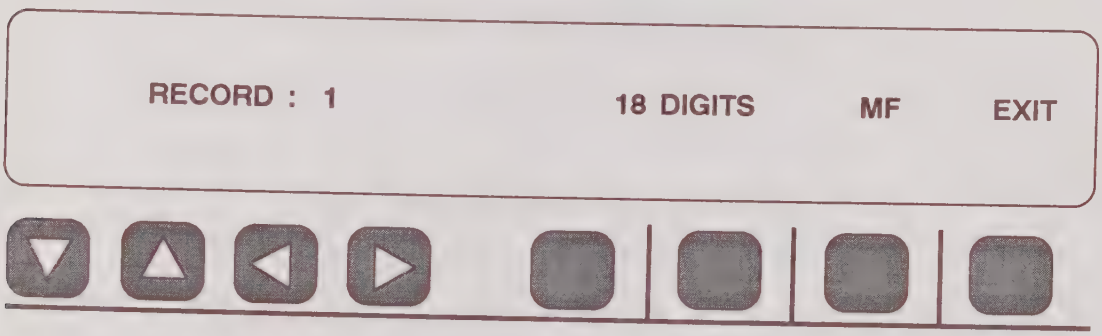


Press Softkey 1 and the 930A display will become:



This is the Digit Receiver Set-Up menu. Pressing either Softkey 1 or 2 enters the parameter (length and type of record) set-up screen. Pressing Softkey 3 enters the sequence set-up screen and pressing Softkey 4 exits back to the primary digit receiver menu.

Press Softkey 1 or 2 and the 930A display will become:

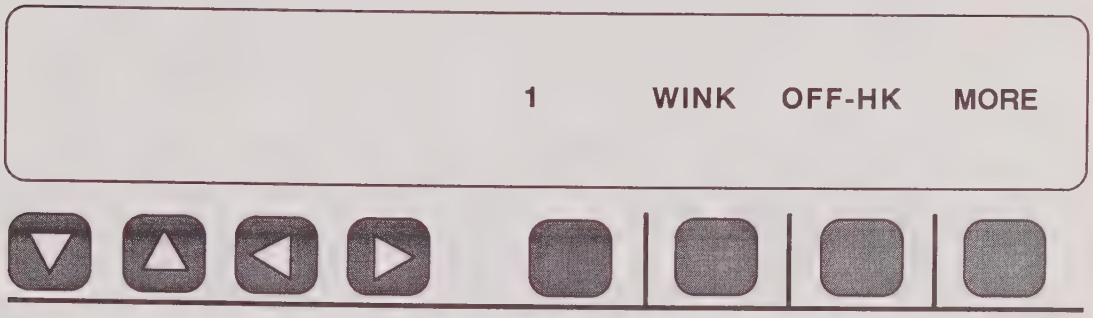


Within the parameter set-up screen shown above, the functions of the front panel keys are as outlined below:

Numeric input is interpreted as the number of digits expected in the record. A length of up to 18 digits may be specified. Larger entries will be truncated. Digit strings of up to 72 digits length can be entered by stringing Records 1-4 together. Start and Stop codes (KP, ST, #, and *) count as digits.

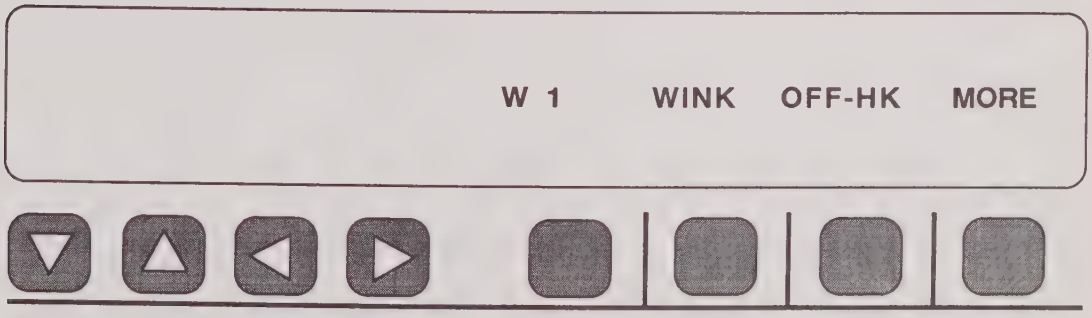
The UP/DOWN arrow keys select the record number which is displayed above them. Up to 4 records may be used.

Example #1: **Immediate Dial**
The originating end will go off hook and send digits. Record #1 has been set up to receive the type and number of digits expected.
The sequence is: 1
The "1" indicates the record number the digits will go into.
Press **1**, **ENT**.
The display will show:

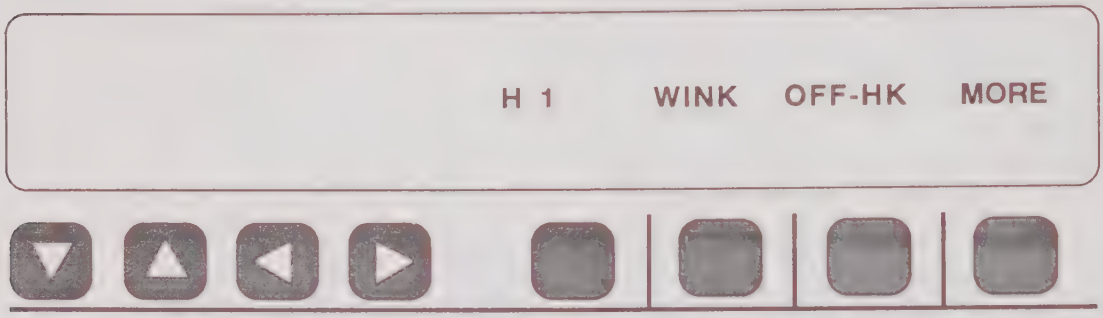


Note that the seizure by the calling end is implicit, **not** a part of the sequence.

Example #2: **Wink Start**
The originating end will seize the line, the terminating end will provide a wink, and the originating end will send digits. Record #1 is set up to receive the digits.
The sequence is: W 1
A wink, followed by the record number the digits will go into.
Press Softkey 2 (labeled **WINK**), **1**, **ENT**.
The display will show:

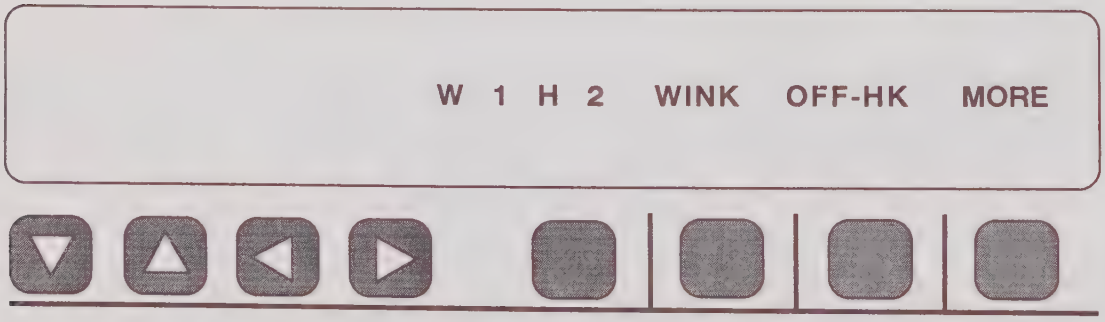


Example #3: **Ground Start**
The originating end seizes (by providing Ring Ground) and then waits for the terminating end to go off hook (provide Tip Ground). It then switches to loop and sends digits. Record #1 is set up to receive the digits.
The sequence is: H 1
An Off-Hook, followed by the record number the digits will go into.
Press Softkey 3 (labeled **OFF-HK**), **1**, **ENT**.
The display will show:



Note that the ring ground and loop by the calling end are implicit. Only the **terminating** supervision is part of the sequence.

Example #4: **TSPS**
The originating office seizes, the terminating office winks, the originating office sends the called number (MF or DP), the terminating office goes Off Hook, and the originating office outpulses the ANI calling number (always MF). Record #1 is set up to receive the called number, and record #2 is set up to receive the ANI calling number.
The sequence is: W 1 H 2
A wink, followed by digits going into record #1, then an Off-Hook, followed by digits going into record #2.
Press Softkey 2 (labeled "**WINK**"), **1**, **ENT**, Softkey 3 (labeled "**OFF-HK**"), **2**, **ENT**.
The display will show:



An example of an equal access call is given in detail in section 4-2 of your manual. Briefly, the sequence at or before the access tandem is W 1 W 2 3 W. An initial wink, followed by an ID code, a second wink, the called number, the calling number, and a final wink. This may be followed by an Off Hook from the terminating end when the call

completes. The access tandem provides the first wink and strips out the ID code, so these are not present on equal access calls where the point of intercept is after the tandem.

Special Sequences:

Ninety percent of the calls made over the Bell system can be described using some combination of winks, off hooks and digits. To insert other events into the sequence, press Softkey 4 (labeled "MORE"). The other choices are:

PAUSE -- pause for one second before proceeding. Use this only when **terminating** a call, never when monitoring. Shows in the sequence as a "-".

D-DIAL -- use for delay dial lines. Terminating end goes On-Hook when ready to receive digits. Shows in sequence as a "D".

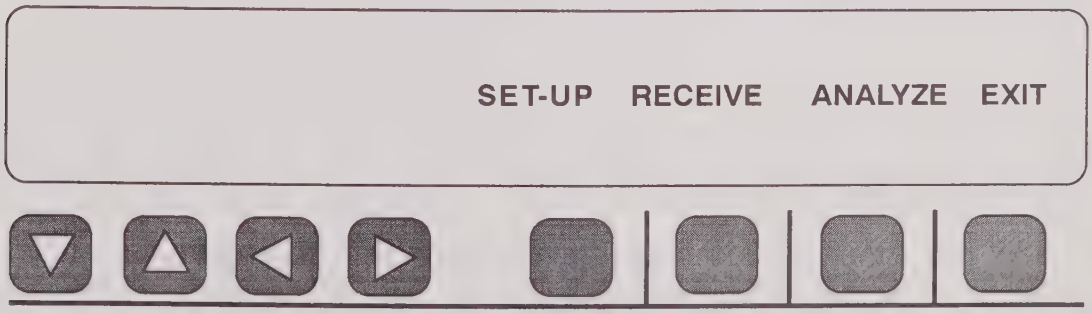
TESTLINE -- Use this only when **terminating** a call. It tells the 930A to go off hook at the end of the call and simulate a testline. You will have a choice of testlines to simulate:

100 -- The 930A goes off hook and provides quiet termination.
102 -- The 930A goes off hook and sends 1004 Hz at -16 dBm.
105 -- The 930A goes off hook and acts as a type 105 responder.
LOOPBACK -- The 930A goes off hook and acts as a loopback testline.

Whatever sequence you set up will be automatically retained in nonvolatile RAM.

3) Receiving the Call

Once you've set up the parameters and sequence, you're ready to start receiving calls. If you're still looking at the sequence set-up menu, press the Option Menu key, then the softkey labeled "EXIT". You should see this display:



Press Softkey 2, labeled "RECEIVE". You should see the display on the following page:

When the calling end seizes the line, you should see the **Orig Off Hook** LED light up. If there is a wink or an off hook in response to the seizure, you should see it on the **Term** LEDs. As the digits are sent, you will hear them over the 930A speaker and see them displayed on the left side of the screen.

As one digit record fills and another begins, the left side of the screen will clear briefly and the new REC# will be displayed, followed by the incoming digits. You can put the 930A on hold at any time by pressing Softkey 3, labeled "HOLD". While the 930A is on hold, it will not receive new digits or clear out the old digits. You can use the up and down arrow keys to view the various records you have received and inspect the digits. Press the softkey labeled "HOLD" a second time to take the 930A off hold and rearm the digit receiver.

After the originating end hangs up, the 930A automatically rearms its digit receiver and prepares to receive another call. It will continue receiving calls until you put it on hold or press the Option Menu key.

The 930A defaults to GATED mode upon each entry to the digit receiver. This means that it waits until it sees an on-hook-to-off-hook transition from the **originating** end before it arms the digit receiver. If you are on a "dry" circuit with no supervision, or if you expect the call to begin without the originating end going off hook, press Softkey 4, labeled "GATED". The label will change to read "OPEN". The digit receiver will now be armed. The 930A will not expect a seizure to initiate the call. When used in open mode, the digit receiver will put itself on hold at the end of every call.

If you put the 930A in PRINTER remote mode, and answer "YES" to the question "PRINT RECEIVED DIGITS? YES NO", the digits received by the 930A will be sent to the printer at the end of each call, any time a wink or supervision event fails, or any time a call is abandoned before completion.

Since the sequence and parameters you set up are retained in nonvolatile RAM, you can skip the set up next time you want to use the digit receiver. Just go to Option Menu 4 and press the Softkey labeled "RECEIVE".

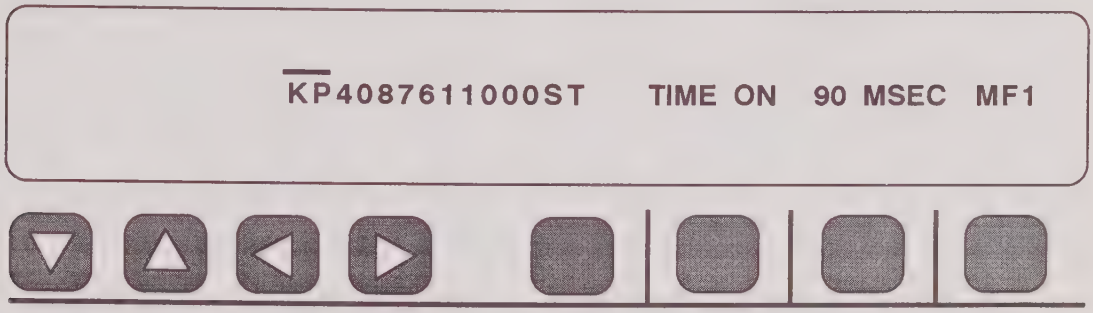
You can store several different sequence/parameter setups in memory at once and call them up as needed. The 930A has thirty-nine general purpose registers for storing test setups. To store a digit receiver setup, exit to the Option Menu and press the **STO** key. You will be prompted to enter a register number in which to store the setup.

To recall a stored setup, go to the Option Menu and press the **RCL** key, followed by the register number in which the setup is stored. You could, for example, have a wink start sequence stored in register 10, a TSPS sequence in register 11 and an equal access sequence in register 12. The most recently used setup is automatically retained when you enter the digit receiver.

4) Analyzing Received Digits

Once you have successfully received a call, you can have the 930A analyze the digits. For MF and DTMF digits, it will report on the amplitude and frequency of the two tones that make up each digit, the frequency and amplitude of up to two additional tones (if spurious tones are present) and the length of each digit and interdigit time in milliseconds. For DP signals, each digit will be analyzed for speed (in pulses per second), %break and interdigit time.

To see the analysis, press the Option Menu key after you have received the call, then press Softkey 3, labeled "ANALYZE". You will see a display much like this:



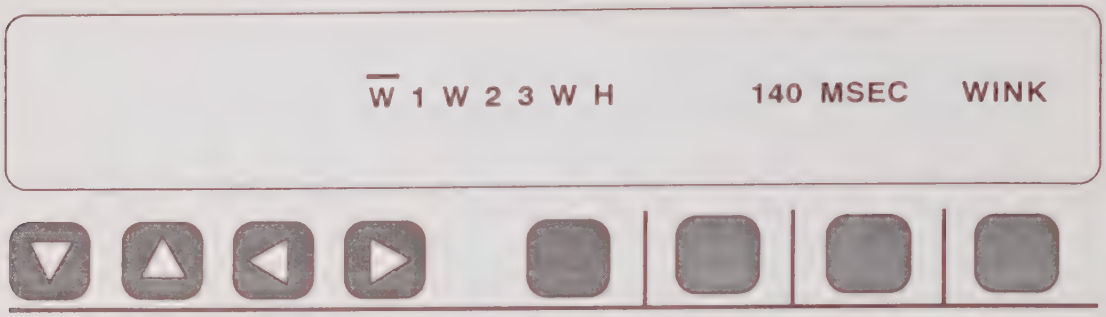
Use the left and right arrow keys to move the cursor over the digit you wish to analyze. Use the up and down arrow keys to scroll through the various parameters, such as TIME ON, TIME OFF, FREQ 1, AMPL 1, %BRK, etc. Press Softkey 4, where the signal type and record number are displayed, to scroll through the four available records. When you have examined the parameters of interest to you, press the Option Menu key to return to the main digit receiver menu ("SETUP RECEIVE ANALYZE EXIT").

If you put the 930A in PRINTER remote mode and answer "YES" to the question "PRINT DIGIT ANALYSIS? YES NO", the 930A will print a complete analysis of all received digits at the end of every call.

5) Timing Winks

If you have monitored a call with winks or off hooks in the sequence, there will be wink timing information available. If the 930A terminates a call, it provides any necessary winks in the sequence. In monitor mode, it looks for and times these events.

To review wink timing information, wait until a call sequence completes or is abandoned. Exit to the Option Menu and go to Option Number 9. WINK TIMING. You will see a display much like this:



Use the left and right arrow keys to move the cursor over the event of interest, such as the first or second wink in the sequence. Press softkey 4 to toggle between the guard time and the event time. The guard time is the time spent waiting for the event. If a wink is the first event in a sequence, the guard time is the time between the seizure and the wink. If a wink follows a digit record, the guard time is the time between the last outpulsed digit in the record and the beginning of the wink. The same is true for an off hook. The event time for a wink is labeled "WINK" and is the actual length of the wink. The length of a successful off hook is labeled as "OFF HOOK" and simply reported as ">200 Msecs". If the terminating end stays off hook for less than 200 milliseconds, the off hook fails.

If you put the 930A in PRINTER remote mode and answer "YES" to the question "PRINT WINK TIMING? YES NO", the 930A will send wink timing information to the printer at the end of every call.

If the 930A is terminating the call, rather than monitoring it, you can set the length of the guard time and the length of the wink sent by the 930A. Go to Option Number 12: Wink Margining. The guard time is called the pre-wink time in this option, and is used to specify how long the 930A will wait before giving a wink or going off hook. The wink time specifies the length of the wink. The factory default is a 200 msec. pre-wink and a 150 msec wink.

SAGE INSTRUMENTS

Model 930A Communications Test Set

Applications Note #1

USING THE DIGIT RECEIVER/ANALYZER

9/10/88

This pamphlet is intended to supplement the description of the digit receiver in section 4-2 of your manual. This will help you to get started. Further information, details and examples can be found in section 4-2. This pamphlet is based on two years of technical support interviews, and addresses the most frequently asked questions.

1) Start out on the right foot:

First, make sure the 930A is set up for the trunk you're testing. Set it to the correct supervision type (E&M, Loop, Gnd-Start, PCM, SF) and impedance. If the 930A is terminating the call, select TERM. If the 930A is monitoring the call, select BRIDGE.

NOTE TO DIGITAL USERS:

Make sure you're on the right PCM channel.
To terminate the span, select TX/RX.
To terminate the call while leaving the span up, select D&I.
To monitor a call, select THRU.
Consult Section 4-6 of the 930A manual for help and diagrams.

Next, make sure the 930A is "looking toward" the caller.

How do you **know** you're in the right trunk type, looking in the right direction? Press the Trunk Type key. When the **caller** goes off hook, the L.E.D. marked **Term Off Hook** lights up. If the Term L.E.D.s don't follow the caller's supervision, something is wrong. (If the **Orig** L.E.D.s follow caller supervision, you're looking in the wrong direction).

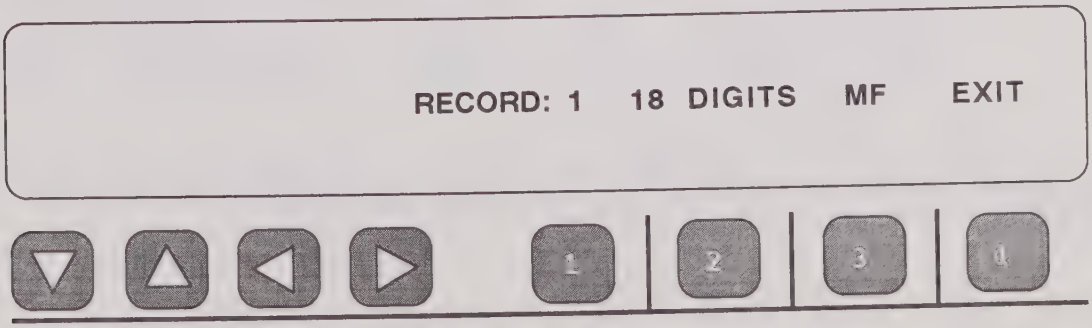
To change direction: In Loop or Gnd-Start, toggle between CONTACT and BATTERY. In E&M, toggle between SEND-E and SEND-M. In PCM, toggle between SEND-1 and SEND-2. In SF, toggle between SEND TR and SEND T1R1. In analog trunks, changing direction will bridge the 930A. If you're going to terminate a call, set the 930A back to TERM.

2) Set it up right:

Once you're on the right trunk and looking in the right direction, you have to tell the 930A what to expect: what kind of digits are expected (MF, DTMF or DP) and how many; are there any winks expected; etc.

The Parameters:

Setting the parameters tells the 930A what kind of digits to expect. Press the Option Menu key. Go to Option Number 4: DIGIT RECEIVER. Select SET-UP. Select PARAMETERS. You'll see a screen that looks something like this:



The 930A can collect digits into four separate registers, called records. Each record can be set to expect MF, DTMF or DP digits, and can hold up to 18 digits.

If you don't set up a record to hold the incoming digits, the 930A won't be able to receive them. The 930A comes factory-set to receive MF in all four records, but any changes you make are automatically saved.

If you're expecting MF digits, set the digit number to the maximum 18. The 930A is smart enough to close the record when it sees a ST, STP, ST2P or ST3P.

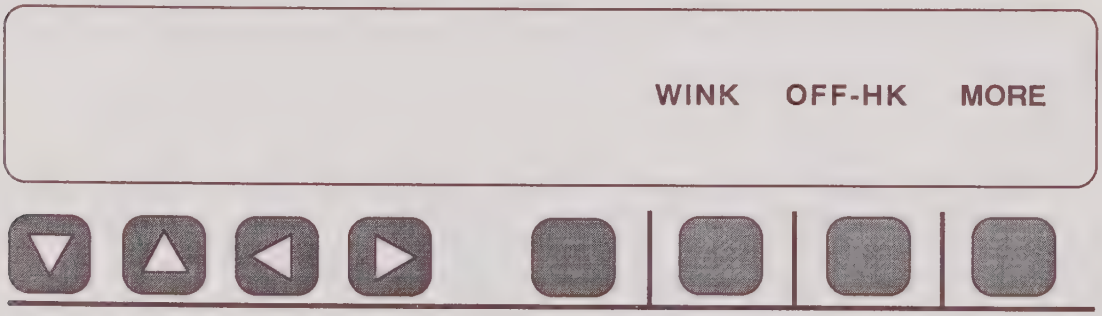
If you're expecting DTMF or DP, set the record to hold the exact number of digits that you expect. Seven digits of DTMF would be typical when monitoring outgoing customer calls from the DEMARC.

Change the number of expected digits by entering a new number from the keypad. Change from MF to DTMF to DP by pressing Softkey 3. Use the up and down arrows to set up as many records as you'll need. Set up a separate record for each string of digits you expect. For a TSPS call, you might set up REC# 1 for 7 DP digits and REC# 2 for 18 MF digits or REC# 1 for 7 DTMF digits and REC# 2 for 18 MF digits.

When you've set up your records, press EXIT (Softkey 4).

The Sequence:

Now you need to set up the sequence. The "sequence" is the expected alternation of digits from the originating end and supervision events from the terminating end. Press Softkey 3 (labeled "SEQUENCE"). Press the **CLR** key to clear out any old sequence. You'll see this display:



The left half of the display is blank. This is where the sequence will be displayed. The next page shows some examples.

NOTE: All sequences **must** include at least one record number (1-4), telling the 930A what record to put the digits into. The 930A will expect the number and type of digits that record is set up for.

Softkeys 1, and 2 are inactive.

Softkey 3 is a wheel which allows the user to select either MF, DTMF, or DP digits.

Softkey 4 exits to the primary digit receiver menu.

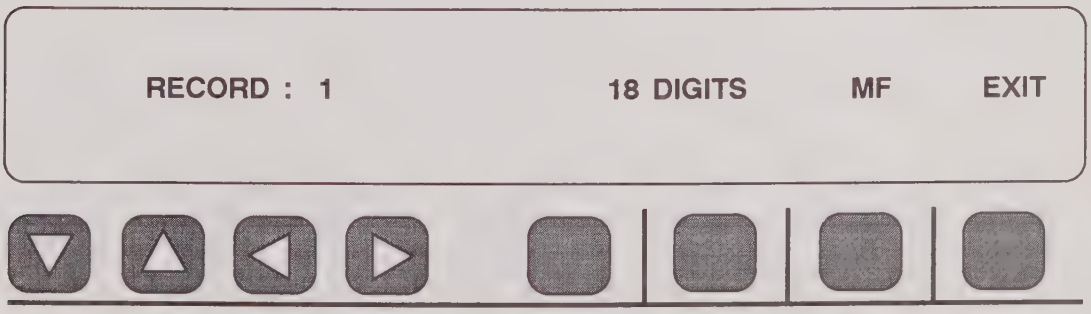
If a received digit string is longer than the length specified, it will spill over into the next record. A string of more than eighteen digits should be set up as two or more records.

4-2.1.1 SETTING RECEIVE PARAMETERS FOR DIAL PULSE OR DTMF

The exact length of the incoming DP or DTMF record must be specified if the 930A is to provide or measure supervision at the end of the record. If no supervision is required the 930A can be considered a wide-open receiver. When one record fills, another will be started and this will continue until record 4 is full.

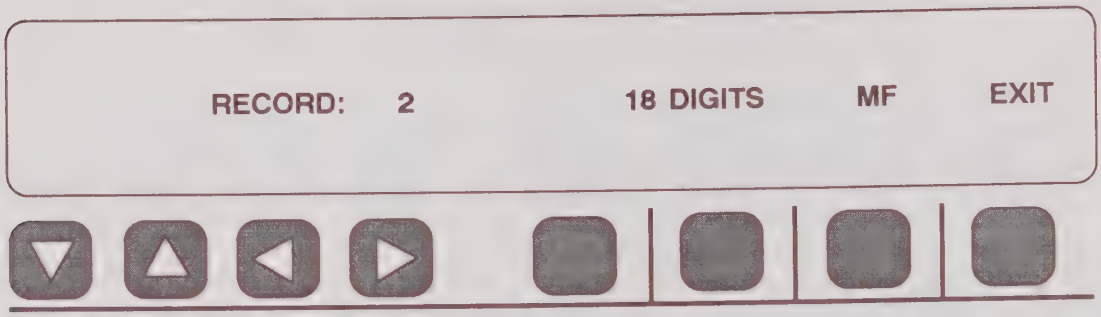
Neither DP nor DTMF strings contain their own delimiters. This presents a problem in multiple record sequences such as TSPS where there exists a mixture of MF (which does have delimiters) and DTMF digit strings.

Using a TSPS trunk as an example, the first two records may be MF while the third record is DTMF (Customer's Calling Card number). Since the calling card number consists of the user's phone number with area code plus a 4 digit personal identification number, it is 14 digits long. The following displays show the set up of the parameters for this example beginning with record number 1 of the 3 record sequence:



Press the UP arrow key if no changes are necessary.

The display will increment to the next record number which, in this example, is also an MF string:

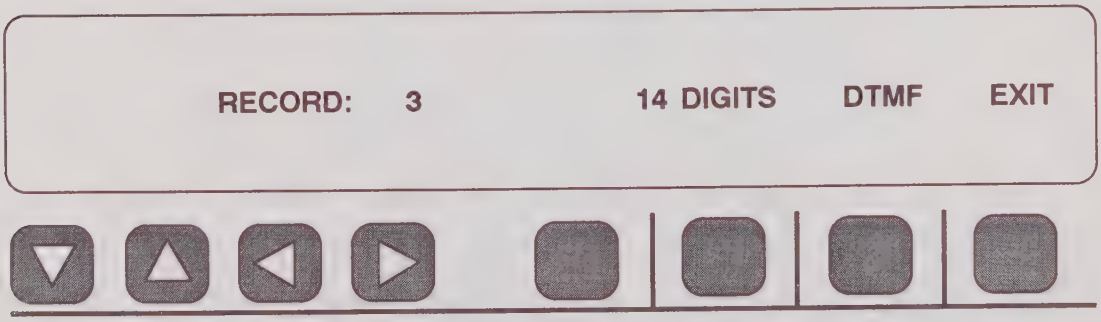


Press the UP arrow key if no changes are necessary.

The 930A display will increment to the third record. The third record, in this example, is a DTMF string. Since DTMF has no delimiters and it is desired to measure supervision events, the exact length of the string (14 digits as mentioned above) must be entered. To do this, perform the following steps:

Press and and then

Press Softkey 3 until DTMF is displayed.



Pressing Softkey 4 (labeled "EXIT") or the Option Menu function key will return the operator to the digit receiver set-up menu.

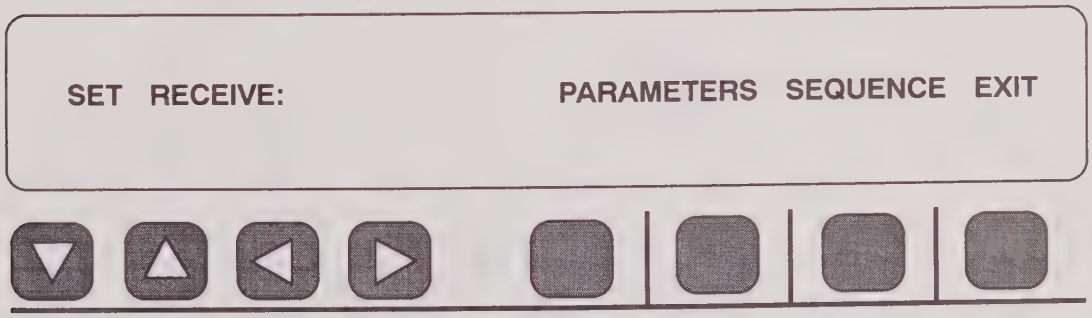
4-2.1.2 SETTING RECEIVE PARAMETERS FOR MF

The MF digit string contains its own delimiters, and the 930A will begin a new record whenever it receives an ST, STP, ST2P, ST3P or when the current record is full, whichever comes first. A record is full when the number of digits received exceeds 18 digits or the number specified for that record.

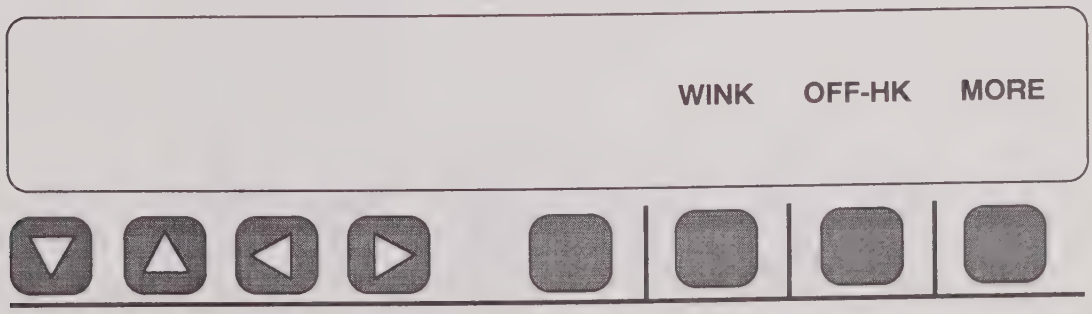
If the 930A is expected to provide a wink at the end of a record, it will do so when it detects an ST, STP, ST2P, or ST3P, or when the current record is full. Since an MF string always contains delimiters, the user need not specify the exact length of the digit string. Instead, it is probably best to simply use the default value of 18 for MF records.

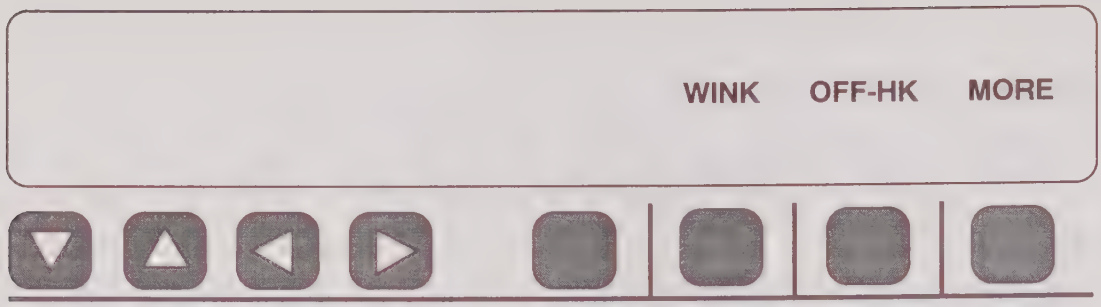
4-2.1.3 SETTING THE RECEIVED RECORDS SEQUENCE

After the Receive Parameters have been set up, the 930A must be programmed for the sequence of records (digit groups) and supervision events (if any) expected. The digit receiver set-up menu is shown below.



Once the parameters have been set up, the operator returns to the above menu by pressing Softkey 4 or the Option Menu key. When the 930A display again appears as shown above, the operator may press Softkey 3 (labeled "SEQUENCE") and the display will change to:





If any previously entered sequence is displayed, it may be removed by pressing the CLR (CLEAR) key. The functions of the front panel keys within this display are as follows:

The Left Arrow key places a one second pause in the sequence.

Numeric input is treated as a record number (1-4).

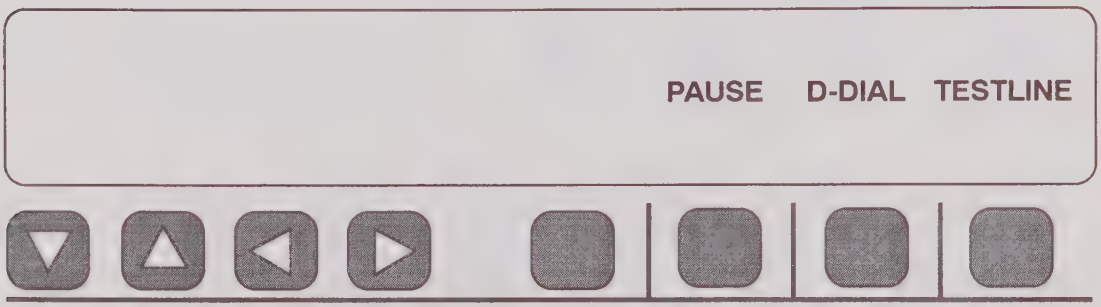
The Clear CLR key clears the sequence.

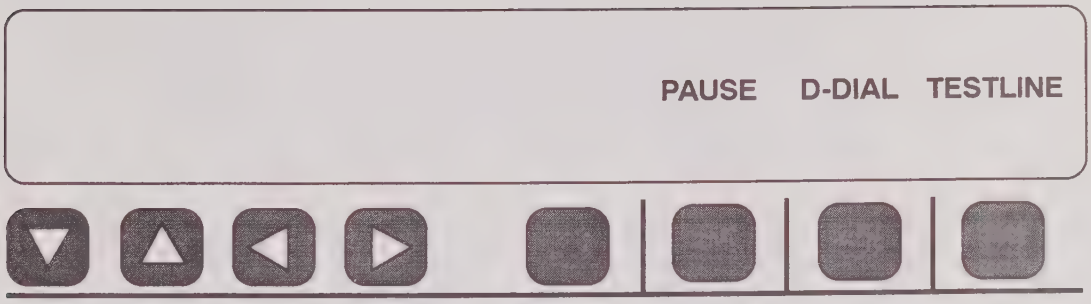
Softkey 1 is inactive.

Softkey 2 places a Wink ("W") in the sequence.

Softkey 3 places an Off-Hook ("H") in the sequence.

Softkey 4 changes the display to show:





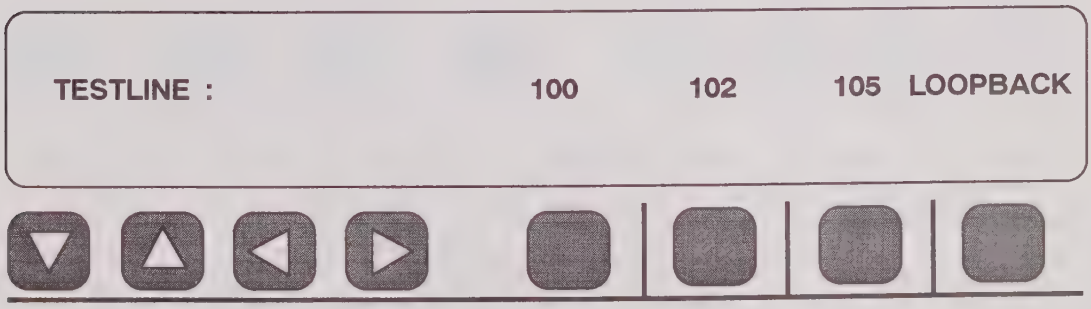
The functions of the Softkeys in this display are as follows:

Softkey 1 is inactive.

Softkey 2 enters a pause (shown as a "-") of about 0.75 seconds into the sequence.

Softkey 3 enters a delay dial event (shown as a "D") into the sequence.

Softkey 4 changes the display to show:



Within this display the function of the Softkeys is as follows:

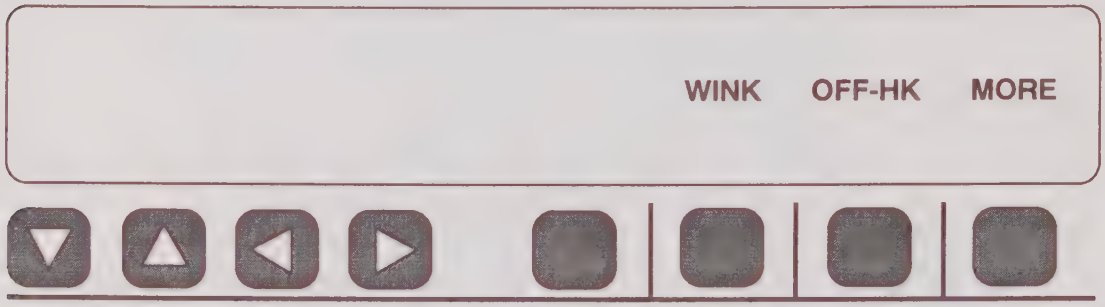
Softkey 1 causes the digit receiver to emulate a Type 100 testline when the sequence is complete. The 930A will provide Quiet Termination until the originating end goes back on hook.

Softkey 2 causes the digit receiver to emulate a Type 102 testline when the sequence is complete. The 930A will send a 1004 Hz tone at -16 dBm until the originating end goes back on hook.

Softkey 3 causes the digit receiver to emulate a Type 105 testline if Option 930A-12 has been installed. The 930A will go off hook and await MF commands from a CAROT compatible tester. Refer to Section 4-7.1 for more details.

Softkey 4 causes the digit receiver to emulate a loopback line when the sequence is complete or after a 2713 Hz loopback tone has been detected. This feature has not been implemented on versions of software prior to Revision 2.06. Pressing this key on early revisions will cause a "NOT INSTALLED" message to be displayed.

After pressing any of these keys the display will return to:

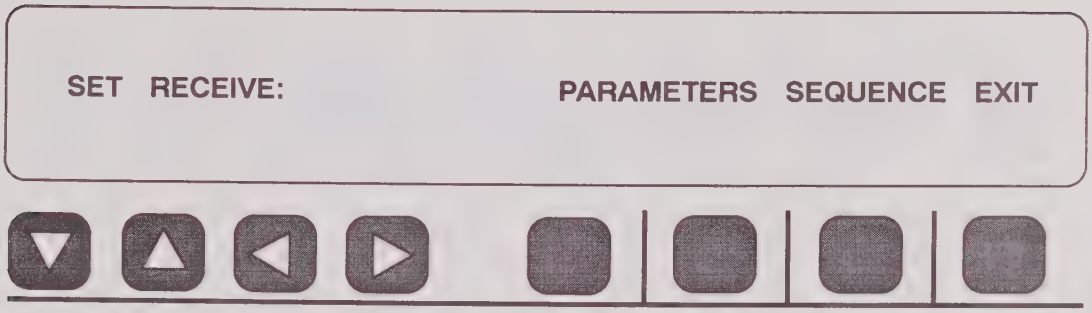


Enter the desired sequence and press the Option Menu function key to return to the digit receiver set-up menu as shown below:

Press Softkey 4 (labeled EXIT) to return to the primary digit receiver menu. To illustrate the use of this menu, the example of an Equal Access type call as presented in Section 3-12.2 will be used to show how to set up a receive sequence.

4-2.1.4 SETTING UP A RECEIVE SEQUENCE FOR EQUAL ACCESS

To begin, the digit receiver set-up menu is repeated below:



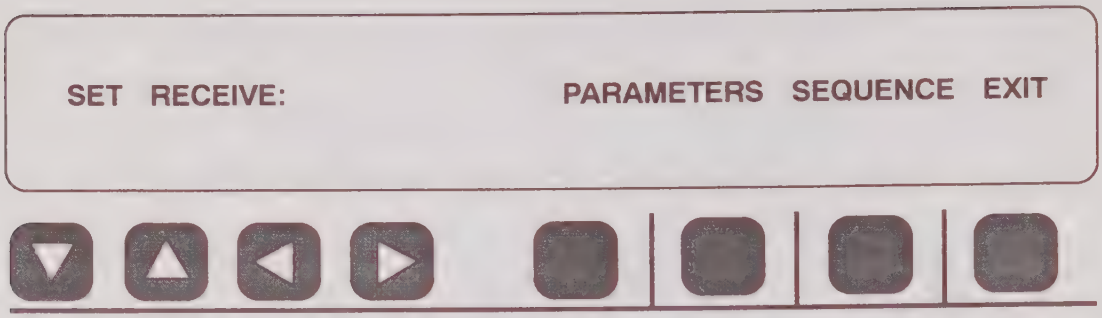
Suppose, for this example, that it is desired to receive Equal Access Feature Group D type calls.

When a call is placed to an Interconnect Carrier (IC) through an access tandem switch, the originating office expects a wink back from the IC to indicate that its receiver is ready to accept digits. The originating office then sends the IC code group of MF digits (for example "KP 001777ST"), and waits for another wink back. When the second wink has been received, the originating office sends the Automatic Number Identification (ANI) or calling number, and the called number (both MF strings), and waits for a final wink to acknowledge call completion.

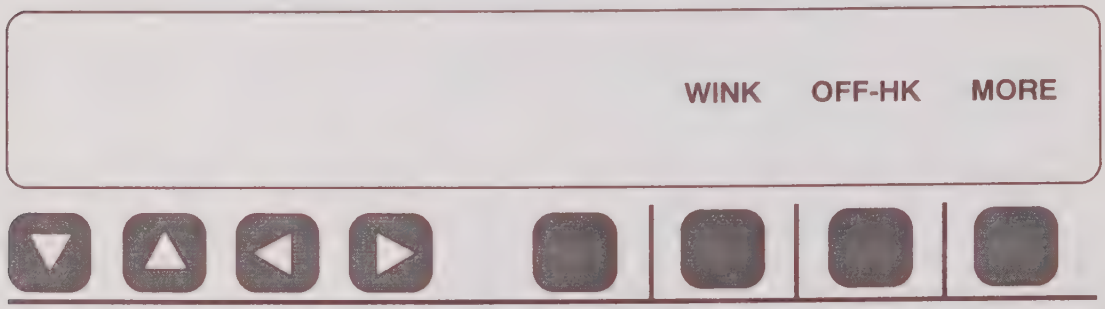
To simulate the access tandem and the IC offices, the received multi-wink sequence will include the IC code, ANI and called number. To set the 930A to receive a complete Feature Group D sequence perform the following steps using the display above as a guide:

Press Softkey 1 (labeled PARAMETERS) and use the UP/DOWN arrow keys to check that the state of each of the records is 18 digits long and that they are set to MF. If not, refer to page 4-8.

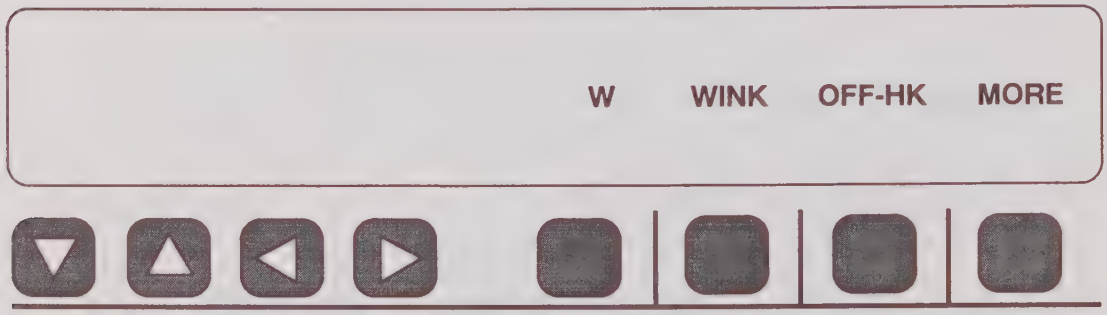
Press Softkey 4 (labeled EXIT) to return to the set-up menu.



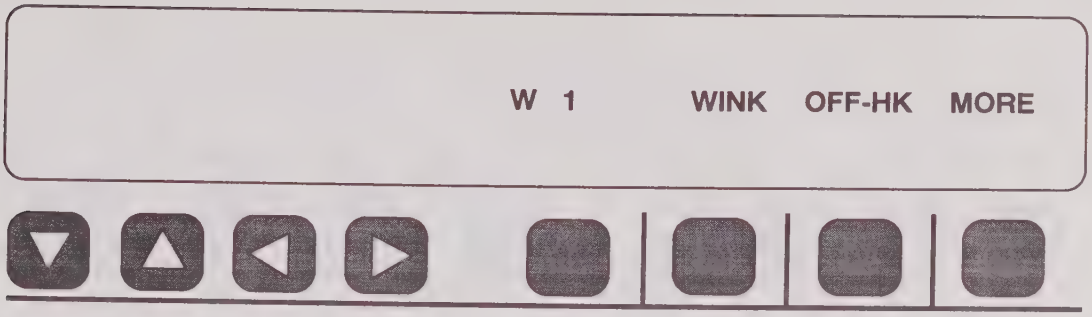
Press Softkey 3 (labeled SEQUENCE) as the first step toward entering the desired sequence. The 930A display will change to:



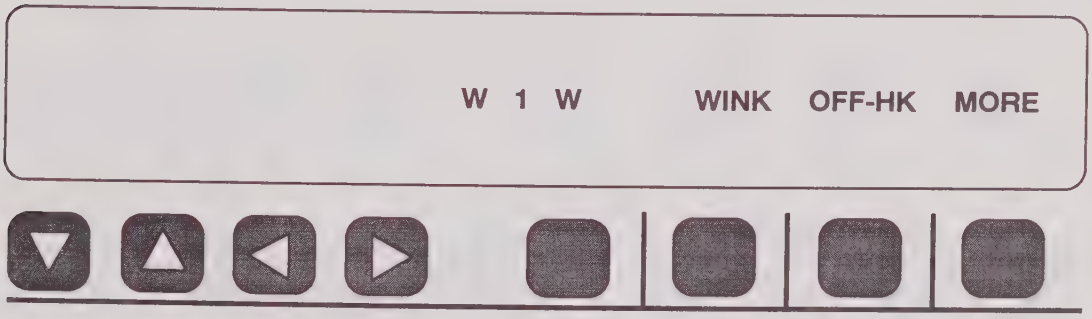
Press Softkey 2 to enter the first wink and the 930A display will change to:



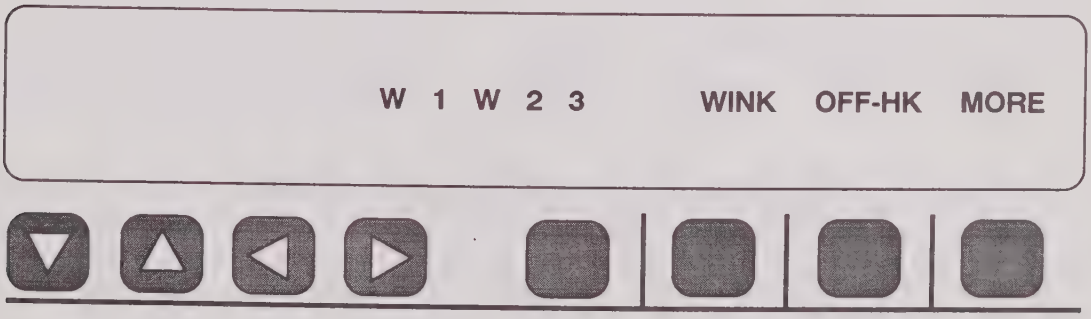
Now the 930A has been set to send a wink. Next, the 930A must be set to receive the first record which in this example is the IC code. To do this simply press the 1 on the numeric keypad and then press the ENTER key. The 930A display will now look like the following:



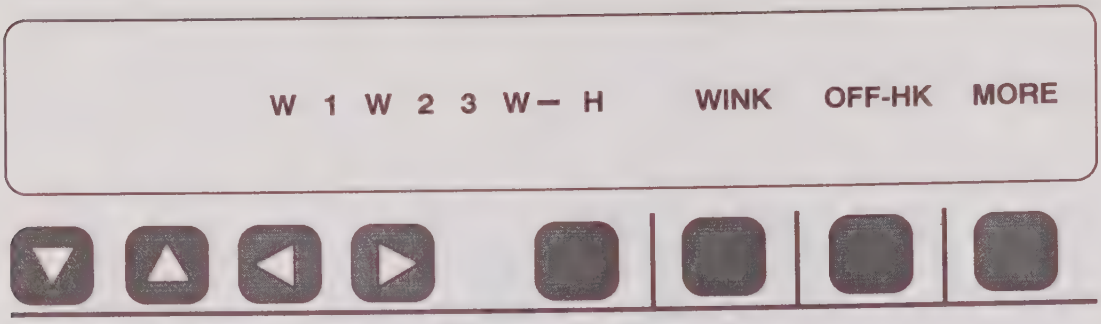
When the first record has been received the 930A must respond back with a wink. Press Softkey 2 to enter the second wink and the display becomes:



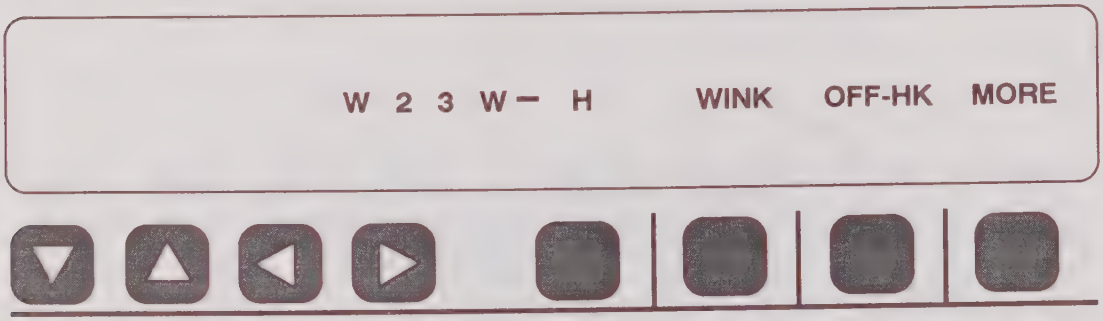
Next, the ANI and the called number will be received as records 2 and 3. To accomplish this simply press 2 and then ENTER and 3 and ENTER and the display will become:



The final wink can now be added by pressing Softkey 2 but the user may also wish to add a pause and an Off-Hook so that the call is allowed to "go Through" and the 930A becomes the called party as well. After the third wink has been added, press the left arrow key to enter a pause and then press Softkey 3 to enter an OFF-HOOK and the completed display will look like:



To simulate the IC alone, simply begin the sequence with the second wink, since the access tandem would provide the first wink and strip off the IC code under these conditions. The sequence, in this case, would look like:



In BRIDGE mode the 930A will not provide the expected supervision since it is in a monitoring mode. The 930A will monitor the interaction between the originating and terminating equipment. This allows the user to receive the incoming digits, and to time the winks and supervision events provided by the terminating equipment.

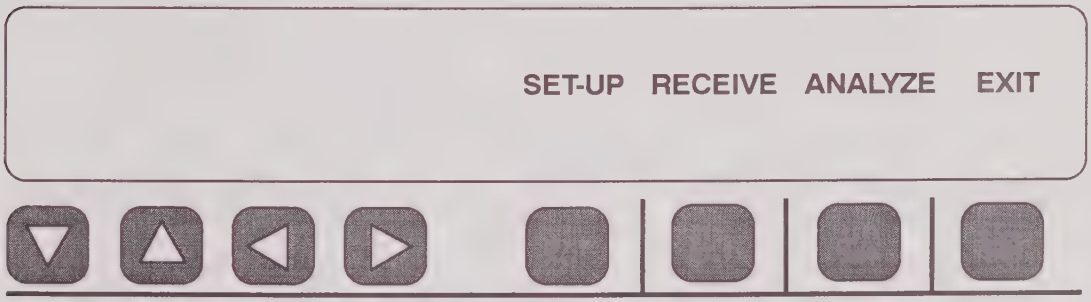
NOTE:

If the 930A has been equipped with option 930A-09 to test T-1 Carrier trunks then the THRU mode is the monitor mode for that option. BRIDGE and TERM affect the impedance only. For a further discussion of the PCM options refer to Section 4-6.

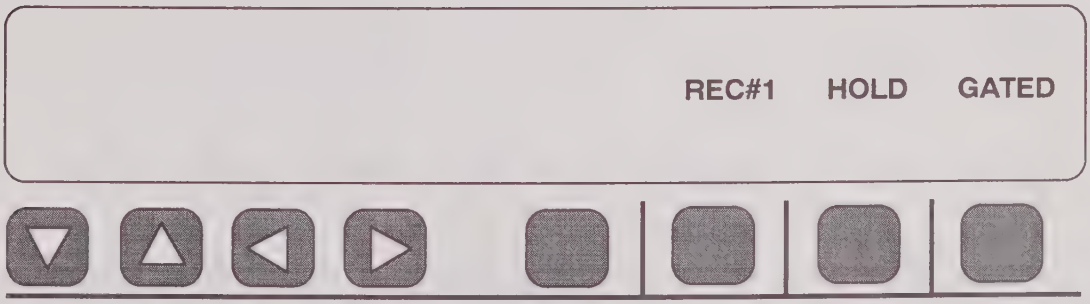
4-2.1.5 RECEIVING DIGITS

Once the operator has defined the length and type of expected records and the sequence of records and supervision, then selecting RECEIVE in the primary digit receiver menu allows the 930A to receive records and to measure or provide answer supervision.

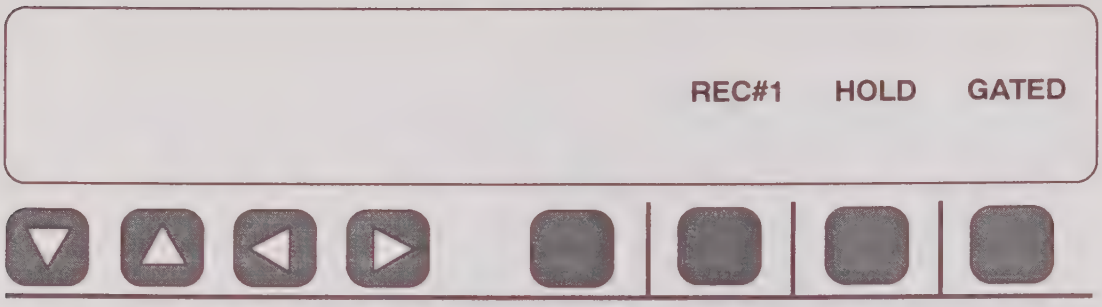
The primary digit receiver menu is repeated below:



With the set-up completed, the operator can enter the digit receiver by pressing Softkey 2 (labeled RECEIVE). The 930A display will change to:



After entering the RECEIVER, press the CLR (Clear) key or Softkey 1 to clear any old records and set the 930A to receive Record 1. The 930A is now waiting for an incoming call. When the originating end seizes the line (Goes off-hook), the 930A will begin the sequence previously entered during the Set-Up phase. The 930A will give the winks, go off hook, pause, or receive and analyze digits outpulsed in MF, DTMF, or Dial Pulse as appropriate.



The operation of the front panel keys within the Receiver is as follows:

Either the CLR key or Softkey 1 will clear previously received digits.

Softkey 2 is inactive.

Softkey 3 places the 930A on "HOLD".

Softkey 4 toggles the 930A between "GATED" and "OPEN" modes.

When the 930A is on "HOLD" it will not receive digits. A talk path is established to the front panel TelSet jacks. The user may scroll through any received digit records using the UP/DOWN arrow keys or Softkey 2 (labeled REC#n). Softkey 3 takes the 930A off "HOLD" if pressed again. When in "HOLD" the 930A displays a flashing cursor above the word "HOLD".

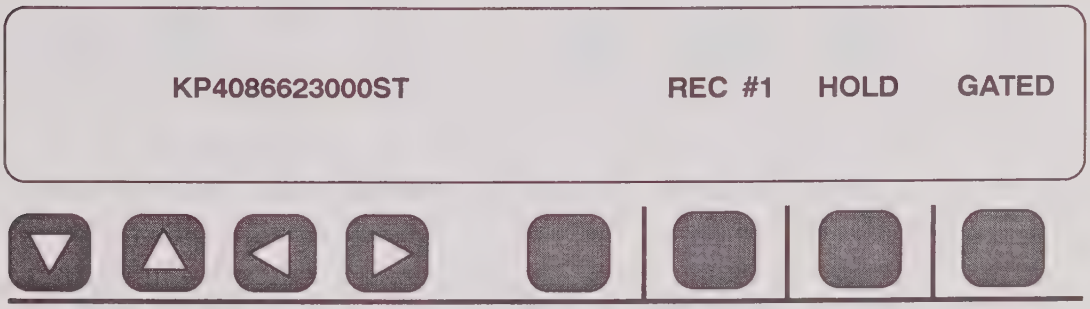
The 930A Receiver can operate in one of two modes: GATED or OPEN. These are chosen by pressing Softkey 4.

When the 930A sees a seizure (a transition from ON-Hook to OFF-Hook on the originating end) in the GATED mode, incoming digits are automatically recorded, records are updated, and the programmed supervision (Winks, etc.) is provided or measured. Digits will be displayed as they are received. Signals which are too distorted to be recognized will be displayed as "E's" (for error).

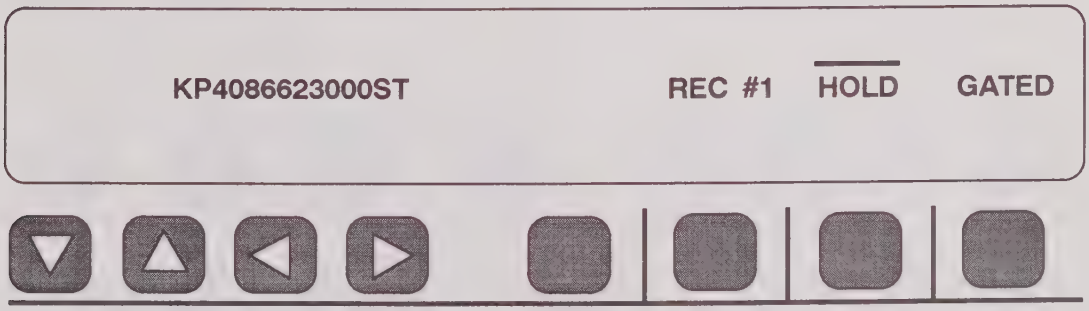
In the OPEN mode, the 930A opens its digit receiver without waiting for an ON-Hook to OFF-Hook transition. This is useful on "Dry" circuits where no supervision is available or in other unusual circumstances. When the sequence completes, the 930A automatically places itself on HOLD and must be re-armed manually. In the GATED mode, the receiver automatically re-arms itself when the originating end goes On-Hook.

If a testline has been selected as part of the receive sequence, the 930A will emulate the chosen testline at the completion of the sequence. When the originating end releases the testline, the 930A will prepare to receive the next digit sequence. Refer to Section 4-7 for more information on the testline option. If the 930A is in the "OPEN" mode, it will place itself on "HOLD" at this point to allow the operator to inspect the received digits.

A typical receiver display, after receiving a record, might appear as:



If the 930A is placed on "HOLD", a flashing cursor appears over the word HOLD and the 930A stops receiving digits. This freezes all records in their current state. The display would appears as:



Timing information, for winks, off-hooks and other supervision events, is available under Menu Option 9: WINK TIMING. This information is obtained only when the 930A is in a Monitor mode (BRIDGE on metallic trunks or THRU on PCM trunks).

NOTE: If receiving records in BRIDGE or THRU modes, place the Hook Switch in the "OFF HOOK" position.

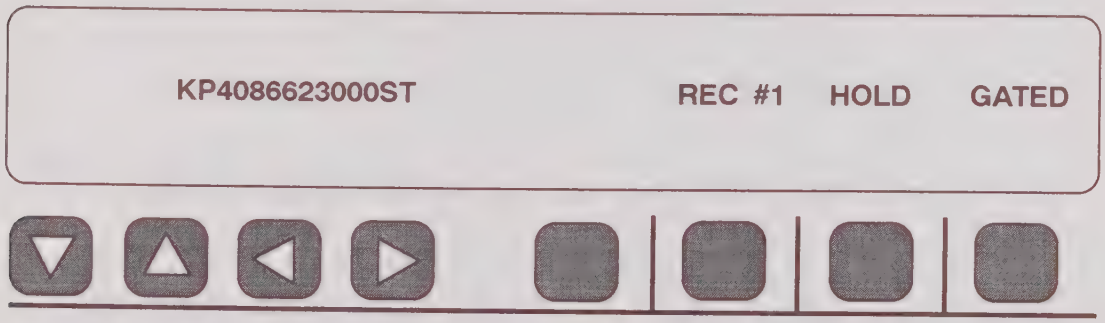
The 930A will send an answer-back tone at the end of a record sequence if one has been selected in the SEND TONE function. This provides an audible acknowledgement that the call has completed successfully.

4-2.1.6 ANALYZING RECEIVED DIGITS

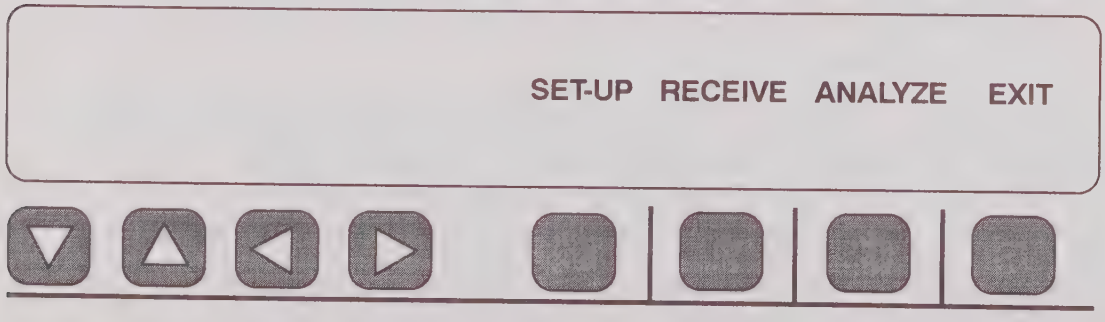
Analysis of received digits, including "Error" digits, is available after digits have been received, by returning to the primary display and selecting the ANALYZE function. The user can analyze the levels of the low and high tones of MF and DTMF sequences as well as their frequencies and ON and OFF times. The user can analyze the % Break, Pulses per second and Interdigit timing of Rotary or Dial Pulse sequences. The amplitude and frequency of up to two additional spurious tones can also be measured.

For instance, the nominal ON and OFF times for DTMF pulses are 50 milliseconds each. Received DTMF records from a "good" source would be expected to be within a few milliseconds of the nominal 50 millisecond value. Values far outside the nominal or large discrepancies between digits in the same record string are symptoms of signaling troubles.

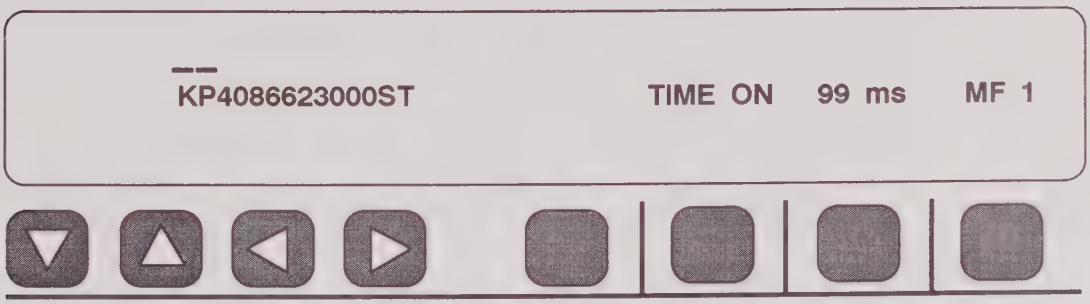
Using the previous example of a single MF digit sequence received in the GATED mode, the display appeared as repeated below:



To analyze these digits it is necessary to return to the primary digit receiver menu. This is accomplished by pressing the Option Menu function key. The 930A display then becomes:

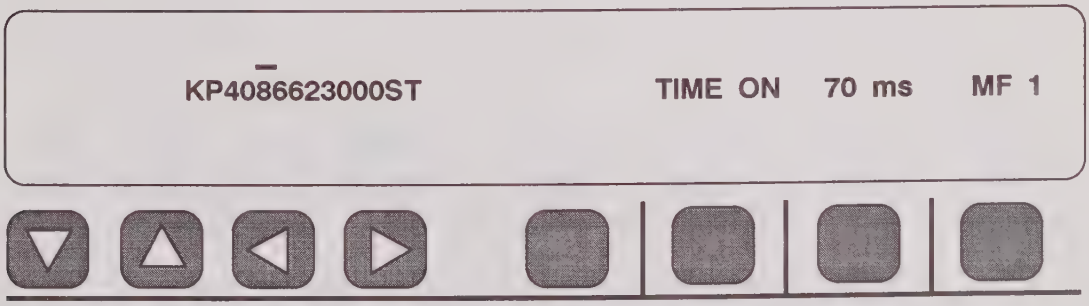


Press any Softkey to enter the option. A typical example of a display is shown below:



The display, in this example shows an MF record. The cursor over the "KP" denotes that it is the digit currently being measured. In this case the ON time of the KP pulse has been measured to be 99 milliseconds.

Use the LEFT/RIGHT arrow keys to position the cursor over the digit to be measured and the display will, for example, look like:

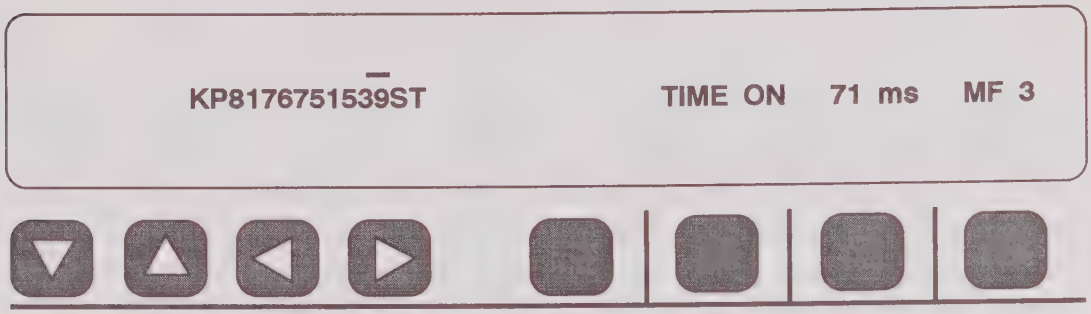


Use the UP/DOWN arrow keys to scroll from the TIME ON to the TIME OFF measurement value and so on through the amplitude and frequency values.

Softkeys 1 and 3 are inactive.

Use Softkey 4 to control which record (1-4) is displayed.

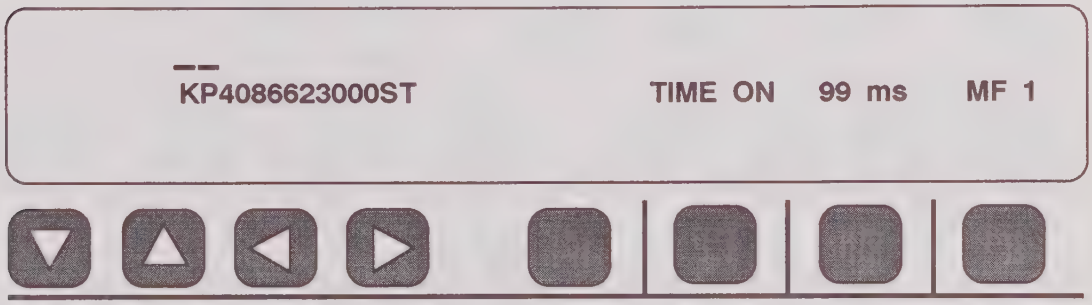
As an example of the types of displays a user might expect to see when using the Digit Analyzer menu option, consider a case where three MF records have been received under the RECEIVE function. After exiting to the primary receiver display and selecting ANALYZE, the Model 930A display will first show the last record received. For this example assume that the display appears as follows:



The third record is displayed and the Time On measurement for the "9" digit is shown. Assume that it is desired to look at the first record received. To go back to record 1, perform the following steps:

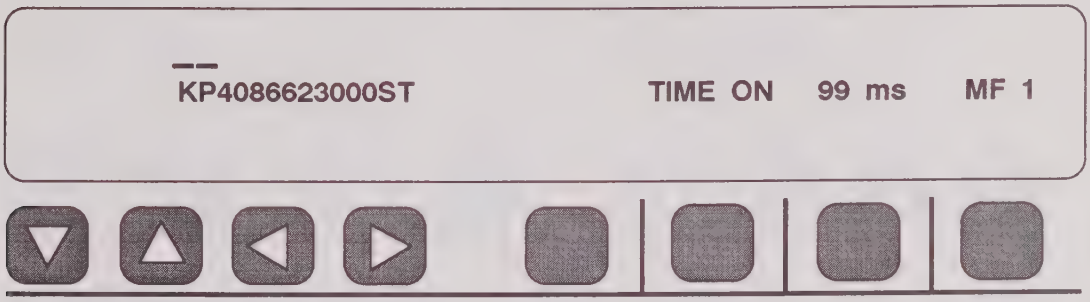
Press Softkey 4 to scroll from MF record 3 to MF record 1.

The Model 930A display is shown below with the first MF record displayed after having scrolled down from the third record.



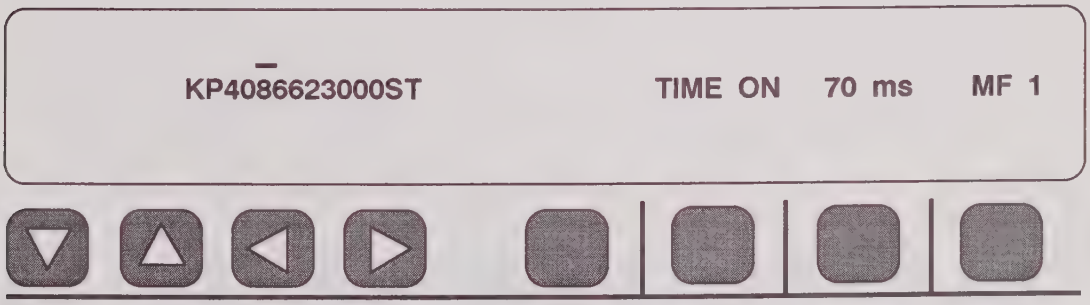
The user may now analyze the individual digits ON and OFF times, and amplitudes and frequencies of the low and high tones.

The displays a user might see while examining a particular digit will be described next. For this example, assume that it is desired to examine the parameters of the "8" in the first MF record sequence shown below.

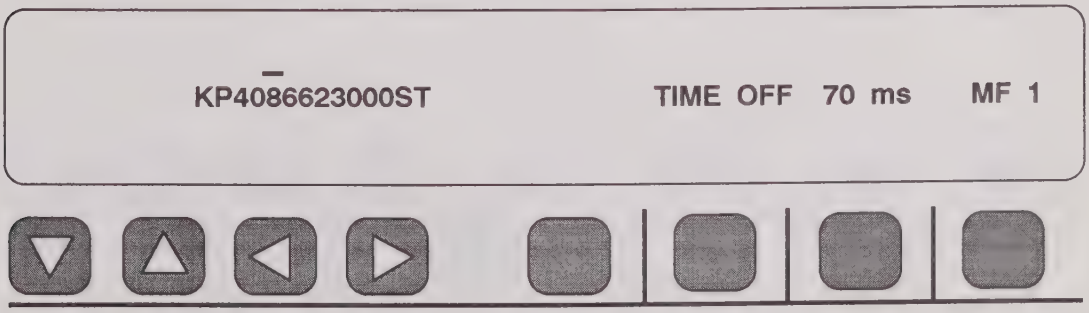


The first step is to reposition the cursor over the digit "8".

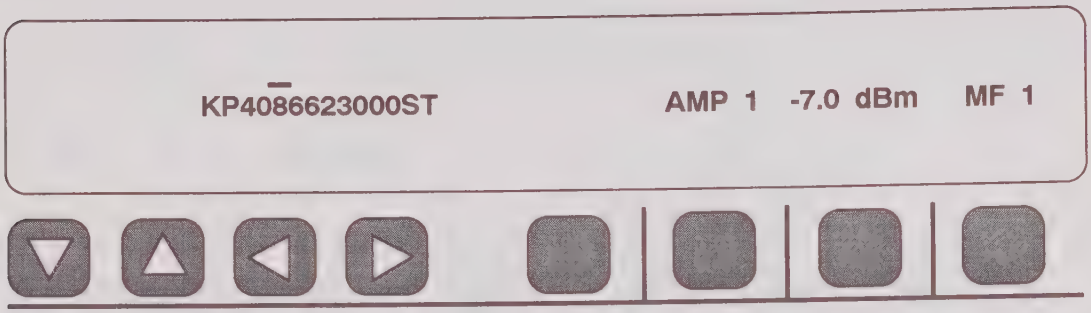
Use the RIGHT arrow key to position the cursor over the "8" and the display will change to:



Now the user may analyze the remaining parameters of the "8" by using the UP/DOWN arrow keys to scroll around from the TIME ON parameter to TIME OFF, AMP 1, FREQ 1, AMP 2, and FREQ 2 measurements as shown below.

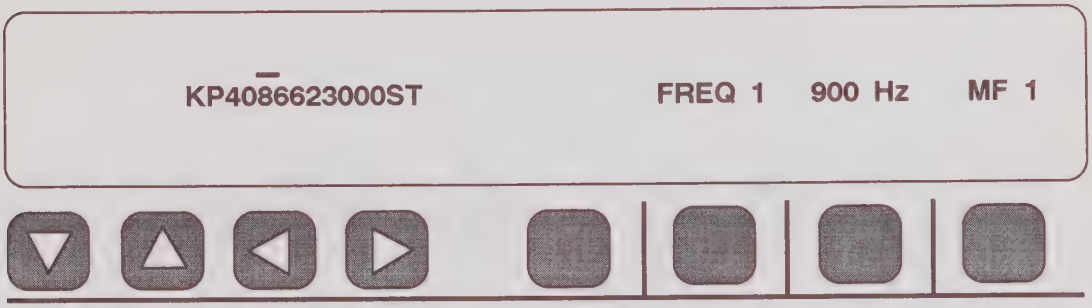


The display of the measurement of the amplitude of the low tone is shown below.

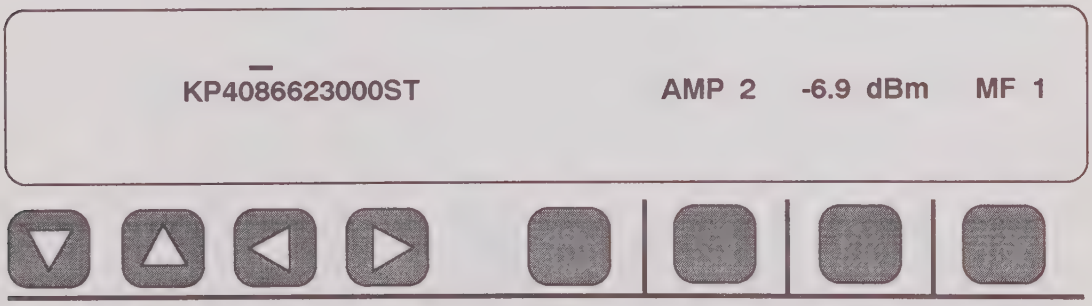


The Model 930A analyzes up to four tones in the ANALYZER mode. The first tone will usually be the low tone of the MF or DTMF digit. The second tone will usually be the high tone of the MF or DTMF digit. Tones 3 and 4 will only be displayed if spurious tones are present. These tones are not necessarily related to the normal high and low tones of the digits.

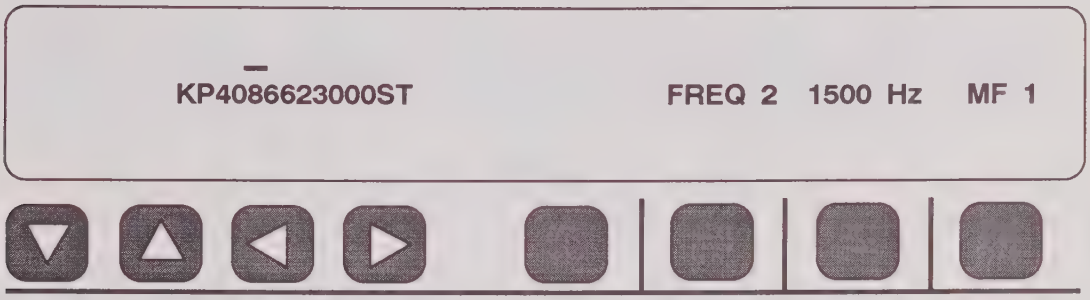
In the above display, if the user presses the UP arrow key again the display will change to show the measurement of the frequency of the Low tone as shown below.



In like manner, pressing the UP arrow key again will change the display to show the measurement of the Amplitude of the High Tone.

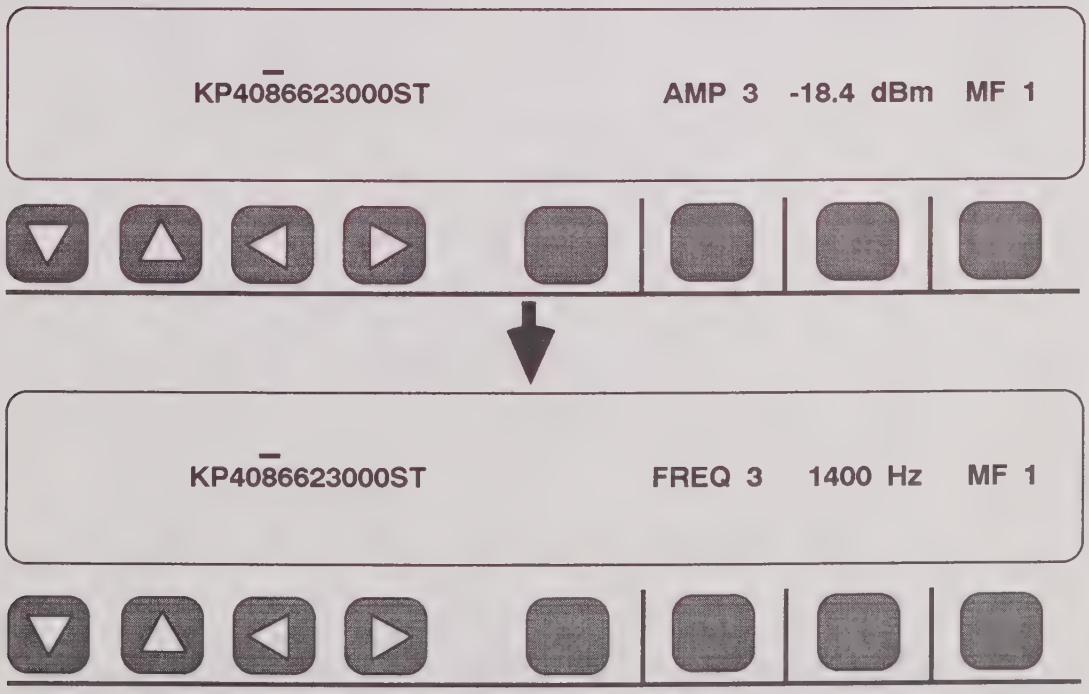


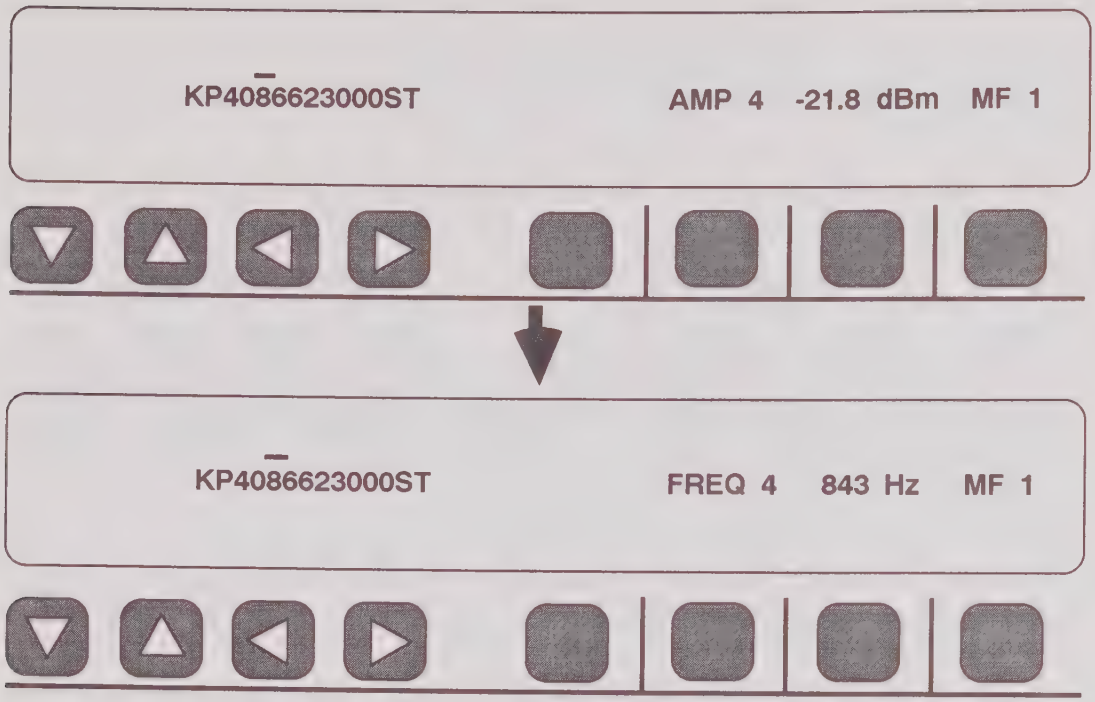
The Frequency of the High Tone of the "8" digit is obtained by again pressing the UP arrow key to bring up the display of the measured frequency as shown below:



Under normal circumstances (i.e., no problems) there would be no displayed values for the amplitude and frequency of tones 3 and 4. If no spurious tones are present, these displays appear briefly and then disappear.

However, for this example, displays for spurious tones are shown in the following:

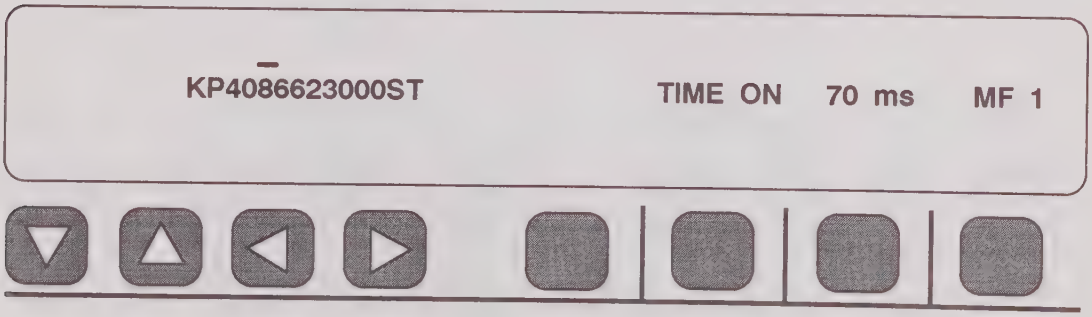


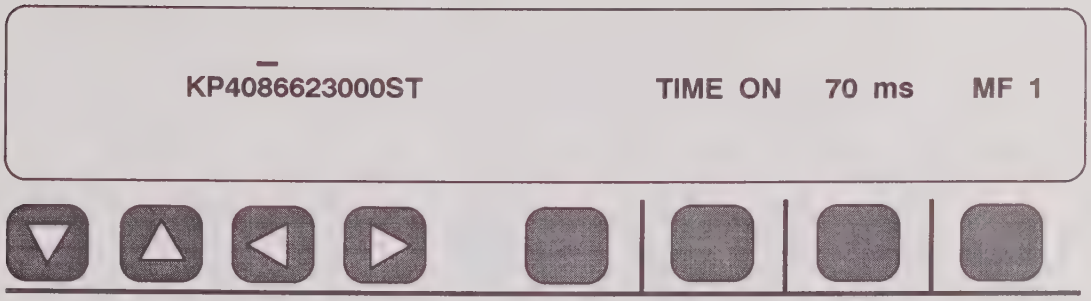


Use the UP/DOWN arrow keys to scroll through the various measurements until returning to the starting point (TIME ON).

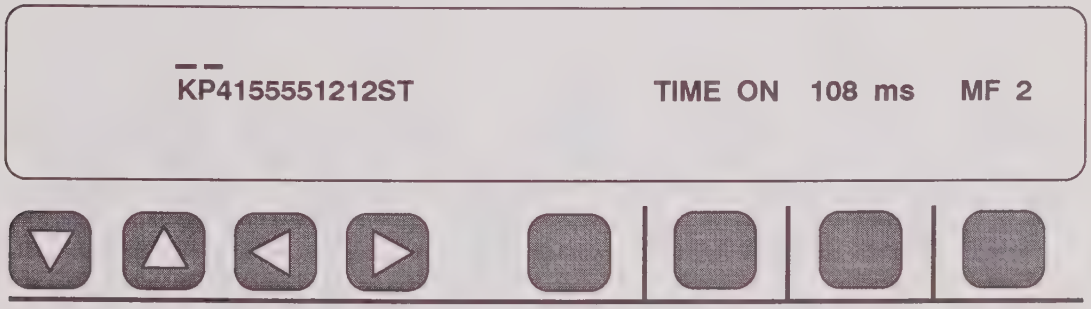
Remember that under normal circumstances, there will be no display of a third or fourth tone. These are displayed only when spurious tones are present.

In order to look at the digits in the other received records (assuming that multiple records were received as in a Feature Group D simulation) the user must use Softkey 4 to move from MF1 to MF2 and from MF2 to MF3 and so on. The following is an example of displays of multiple records. The previous display of the digit string of MF record 1 is repeated below:



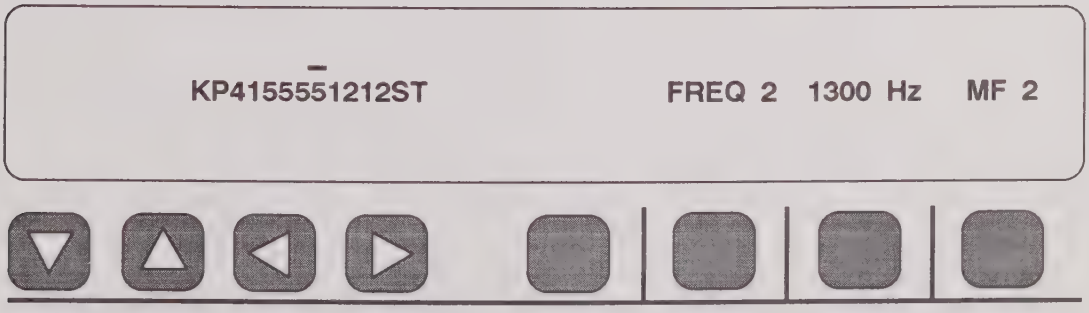


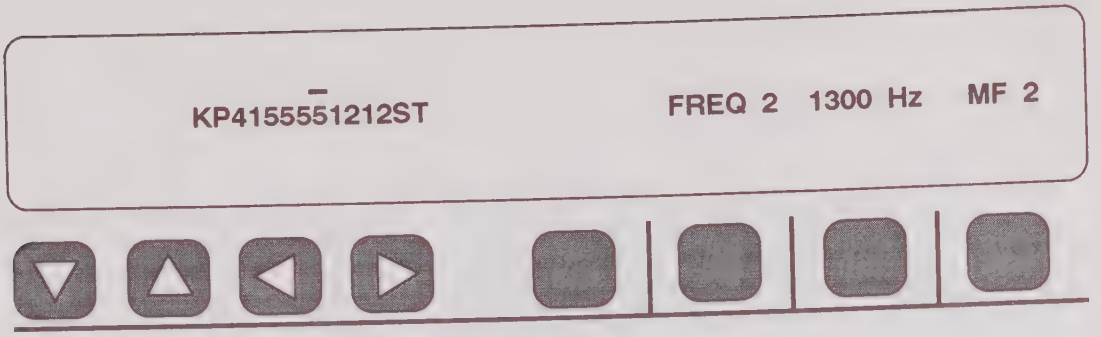
Press Softkey 4 to change from MF record 1 to MF record 2. A sample display of a second MF record follows.



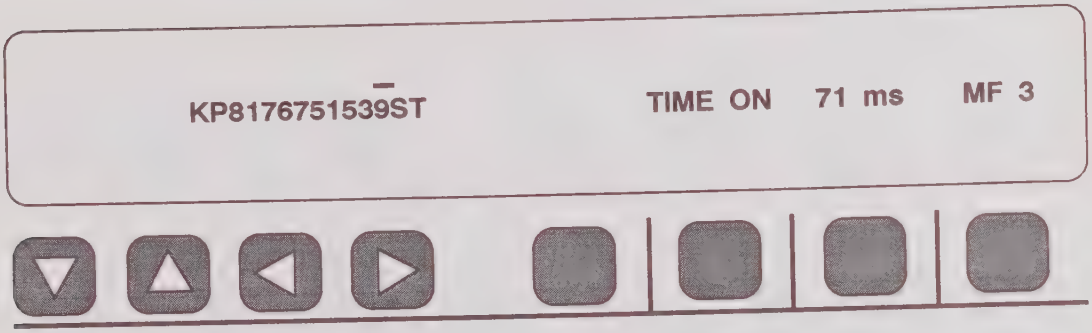
The user may now analyze each digit in the above MF sequence in the same manner as was previously applied to analyzing record 1. The LEFT and RIGHT arrow keys move the cursor to the digit of interest. The UP/DOWN arrow keys then scroll through the measurements of the parameters.

A typical parameter measurement of a digit in the second record is shown below:





Press Softkey 4 to change from MF 2 to MF 3 and the third record appears.



In actual use it can be expected that the digits will be less than perfect. In fact, some or all of the digits may be so badly mutilated that even the 930A will not be able to interpret them. In such a case the 930A display will show an "E" instead of the received digit. Such displays are discussed in the example which follows.

After this example, there are sections which provide the nominal expected values of the MF, DTMF and DP digits as well as their out of service limits.

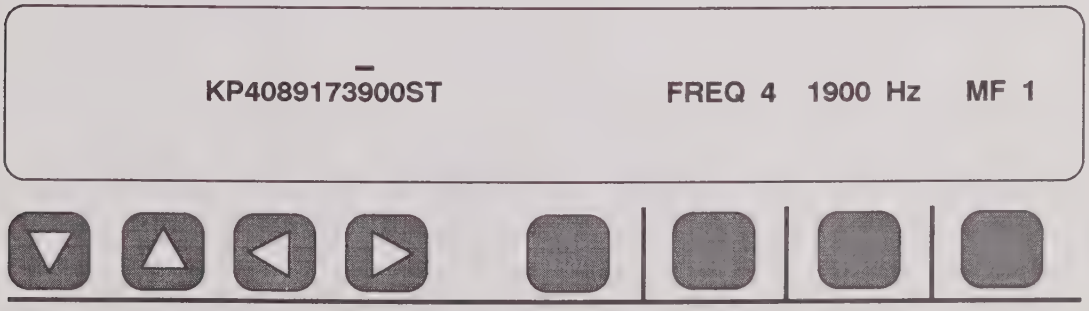
4-2.1.7 EXAMPLE OF ANALYZING RECORDS

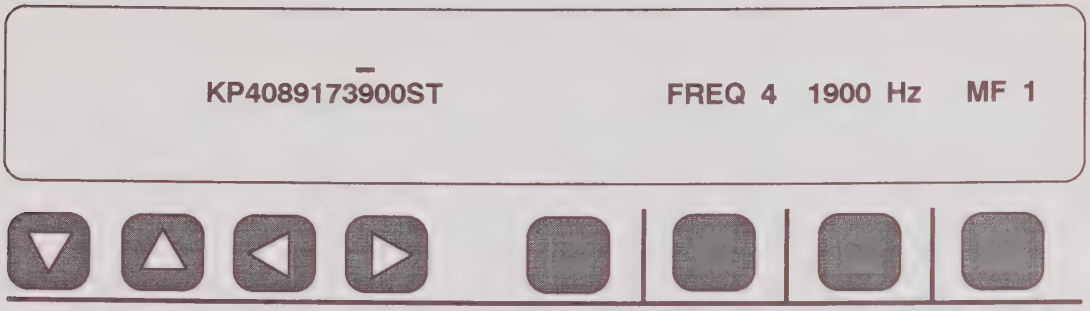
When analyzing a string of received digits it is quite possible that some of the digits may be so badly mutilated that they are not recognizable. This can be caused by any number of things including defective sending equipment, pressing two keys at the same time and causing more than two tones to be sent in MF, and weak DTMF keypad springs in touchtone phones which distorts the digits.

A typical display of distorted digits might appear as follows:

In the above display a number of the DTMF digits were not recognizable. If the operator knows what digits were actually sent this may help to determine the cause of the problem. For instance, suppose that the string of digits was sent as 4156779124. An examination of the high and low group frequencies which make up these tones quickly shows that the item common to each of the missing digits is the 1209 Hz High tone. This may be due to low amplitude, a defective keypad or any number of items.

In the next example, a 930A placed on the interoffice trunk between two switches displays more than the expected MF digits. The display shows two extra tones at unexpectedly high amplitudes. An example display of one of the extra tones is shown below:





In this case, our first inclination is to suspect that the tone may be an actual MF tone, perhaps caused by a generator stuck on. An examination of the MF tone frequency table however shows us that the MF tones are combinations of 700, 900 1100, 1300, 1500 and 1700 Hz. So, where did the 1900 Hz come from?

Whenever more than one frequency is present, the possibility of intermodulation products is a consideration. The mathematical formula used for computing first order intermodulation products has the form 2A-B or 2B-A where A and B are any of the MF tone pairs in this case.

Consider the tone pair 1100,1500 (MF digit 9) and let A=1100 Hz and B=1500 Hz. In this case, 2B-A becomes (2x1500)-1100=1900 Hz. So now we know that the tone is related to the MF digits but we do not know why.

The fact that the spurious tone was the result of an intermodulation product provides us with an important clue. Intermodulation products require a nonlinearity in order to be produced. This is used for constructive purposes in such devices as Mixers. However, nonlinearities can appear under uncontrolled circumstances.

In our example we have chosen to look at a trunk between two switches. Suppose one switch is a new digital machine while the other is an older analog type. If the tone output levels from the analog switch are "hot" they can easily over drive the input circuits of the digital switch. The digital switch, being new, uses integrated circuits which are basically collections of transistors. As such they can provide the nonlinearity quite easily if they are over driven. This is not an uncommon problem and requires the engineer to check the levels coming from the analog switch and set them back to normal levels acceptable to the far end switch.

4-2.2 SIGNALING PARAMETER VALUES

This section deals with the expected values of the MF, DTMF and DP parameters which the operator may receive. It is intended to provide a basis for determining whether or not the digits being analyzed are in or out of specification and thus aids in troubleshooting.

4-2.2.1 MULTIFREQUENCY (MF)

It is important to note that MF is only found on trunks between switches. It is not used on the subscriber side of a switch out to a customer premise. It is how the central office switches along a calling path "talk" to each other. MF consists of 15 digits which are listed in Table 4-2 along with the nominal frequencies of the tone pairs which form them.

TABLE 4-2
MULTIFREQUENCY (MF) CODES

FREQUENCIES (Hz)	DIGIT AND CONTROL	SIGNALS EXPANDED INBAND	CCITT NO. 5	TSPS/EQUAL ACCESS
700+900	1			
700+1100	2	COIN COLLECT		
700+1300	4			
700+1500	7			
700+1700		RINGBACK	CODE 11	ST3P (ST''')
900+1100	3			
900+1300	5			
900+1500	8	OPER. RELSD		
900+1700			CODE 12	STP (ST')
1100+1300	6			
1100+1500	9			
1100+1700	KP	COIN RETURN	KP1	
1300+1500	0	OPER. ATTCHD		
1300+1700			KP2	ST2P (ST'')
1500+1700	ST	COIN COLLECT		ST
		OPER. RELSD		

The discrete tones of the MF oscillators are seen to be 700, 900, 1100, 1300, 1500 and 1700 Hz. These frequencies should be within +/-1.5% of their nominal values or the switch may declare them in error.

The measurements of these tones with the 930A digit analyzer should therefore fall within the following ranges:

700+/-10 Hz
900+/-13 Hz
1100+/-16 Hz
1300+/-19 Hz
1500+/-22 Hz
1700+/-25 Hz

The signal duration, sometimes referred to as interdigit time or ON/OFF time, varies with the type and vintage of the switching equipment. Most modern digital switches have an interdigital interval of 70 milliseconds for MF digits. The Keypulse (KP) however, typically lies between 90 and 120 milliseconds. Receivers are designed to receive a KP signal of 55 milliseconds minimum duration.

The nominal KP and digit intervals for several commonly used switching machines are shown in Table 4-3.

TABLE 4-3
MF SENDER INTERDIGIT INTERVALS

SWITCHING SYSTEM	KEYPULSE (Milliseconds)	NORMAL PULSE ON/OFF TIMES (MS)
Step By Step	100+/-10	68+/-7
No. 1 Crossbar	100+/- 10	68+/-7
No. 5 Crossbar	100+/- 10	68+/-7
Crossbar Tandem	100+/- 10	68+/-7
No. 4 Crossbar	100+/- 10	68+/-7
No. 1E/1AESS	120+/-0.5	60+/-0.5
No. 2E/2BESS	100	75
No. 3ESS	100	70
No. 4ESS	100	70
No. 5ESS	110	70
DMS-10	100+/-10	68+/-7
DMS-100F	100	70

The 930A default values for sending MF are 100 msecs. for the KP and 70 msecs. ON/70 msecs. OFF for pulse times.

The output levels of the tone oscillators also varies with the vintage of the equipment. The older switching systems transmit at -6 dBm0. That is, they send at 6 dBm below the 0 dB Transmission Level Point (TLP) per frequency. Therefore, tones sent at a -16 dB TLP would be expected to arrive at a -22 dBm level which in this case is - 6 dBm0.

Newer equipment transmits at -7 dBm relative to the TLP or -7 dBm0. The tolerance is +/-1 dBm and the levels of the two tones received should be within 1 dB of each other for each digit. Also, any spurious tones should be at least 30 dB below the level of the desired tones over a 3 KHz band.

4-2.2.2 DUAL TONE MULTIFREQUENCY (DTMF)

Dual Tone Multifrequency (DTMF) or touch tone provides a method of pushbutton dialing from customer station equipment to the telephone Central Office switch. Prior to DTMF there was only Dial Pulse or rotary dial station equipment.

With DTMF, dialed digits are composed of two non-harmonically related tones. The nominal values of these frequencies are shown below:

		HIGH GROUP FREQUENCIES (Hz)			
		1209	1336	1477	1633
LOW GROUP FREQUENCIES (Hz)	697	1	2	3	A
	770	4	5	6	B
	852	7	8	9	C
	941	*	0	#	D

The digits are composed of a tone from the Low Group and one from the High Group. For example, the digit 9 in DTMF would consist of the 852 Hz and 1477 Hz tone pair. Receiving equipment in the Central Office is designed to accept and register digits that are within +/-1.5% of the nominal frequency values. Receivers should be designed not to register digits if either tone frequency deviates more than +/-3.5% from the nominal frequencies.

Receiving equipment should register DTMF digits as short as 40 msecs. ON and 40 msecs. OFF. The shortest Tone ON plus Tone OFF interval which must be accepted is 93 msecs. Digits less than 23 msecs. duration should be rejected.

The nominal DTMF sender tone level is -7 dBm+/-0.5 dBm per frequency relative to the 0 dB TLP. Receiving equipment should register digits over a -25 to 0 dBm range and reject digits if either frequency is below -55 dBm.

4-2.2.3 DIAL PULSE (DP)

Dial Pulse or Rotary Dial customer station equipment is another means of transmitting digit information from the customer to the Central Office switch.

Modern dial pulse equipment is designed to a Break ratio of 58 to 64%. The 930A default value is 60%. The pulsing rate or speed is 10+/-0.5 PPS in new equipment with a 700 millisecond interdigital time interval. An accuracy of +/-5% is considered satisfactory in this interval although modern switches are capable of accepting intervals as fast as 70 msecs. and as slow as 1000 msecs.

Older equipments were manufactured to wider tolerances and can be expected to range from 7.5 to 12 PPS speeds and 59.5 to 67.5% Break.

Some 20 PPS equipment is still in use and may be expected to range from 17 to 21 PPS speed and 62 to 66% Break.

The interdigital time of 700 msecs. is the recommended interval and should be used to prevent call failures. It is better to have a longer interval than a shorter one so when analyzing DP with the 930A, look for intervals below 700 msecs. as a possible cause of call failures.

4-2.3 MENU OPTION NUMBER: 12 WINK MARGINING

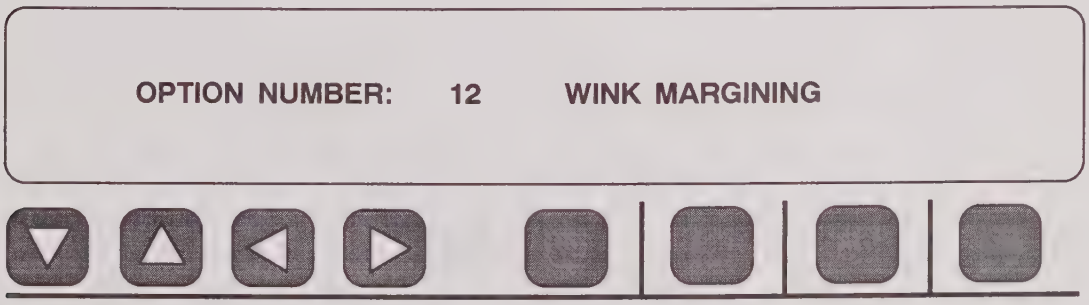
The Model 930A includes Wink Margining as part of Option 930A-01 (MF, DTMF, and DP Receiver/Analyzer). If this option has been purchased and installed, then the 930A will enable the user to modify the wink parameters. The Wink Margining menu option is used to modify the length of time the 930A waits before giving a wink and to modify the length of the wink itself. This feature is most useful in determining Pass/Fail margins of transmitting equipment.

Select Menu Option 12 in the same manner as any other menu option by the following steps:

Press the OPTION MENU function key.

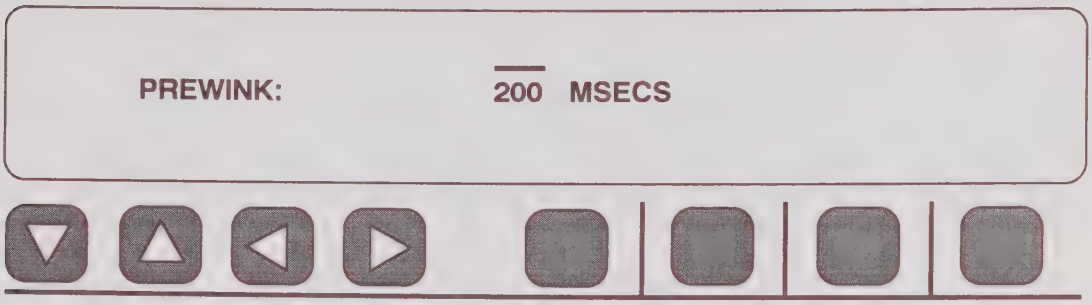
Use the UP/DOWN arrow keys to select Menu Option 12, WINK MARGINING.

The 930A display will appear as shown below:



Enter the menu option by pressing any Softkey.

Once inside Menu Option 12, the display will show the default value of the "Pre-Wink", or the last value entered.

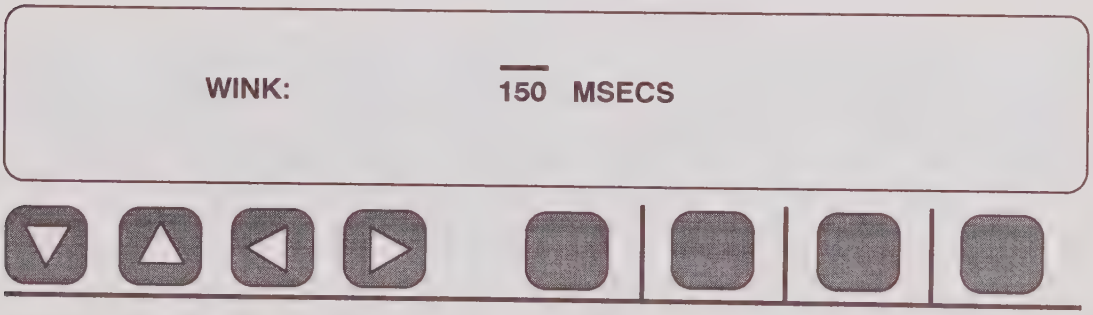


The "Pre-Wink" time is the number of milliseconds the 930A will wait after line seizure (or the end of a record) before giving a wink. The range of permissible values lies between 55 and 995 msecs. The factory set default value is 200 msecs. This option has a resolution of 10 msecs. and an accuracy of +/- 10 msecs. The front panel keys function as follows:

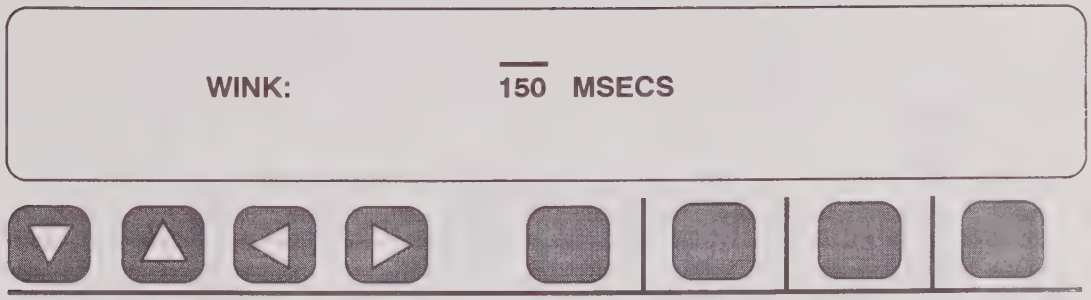
Input from the numeric keypad is treated as a pre-wink period.

Pressing ENTER or any Softkey locks in the displayed pre-wink value and advances to the next screen.

The display will then read the Wink Time default value of 150 milliseconds or the last value entered:

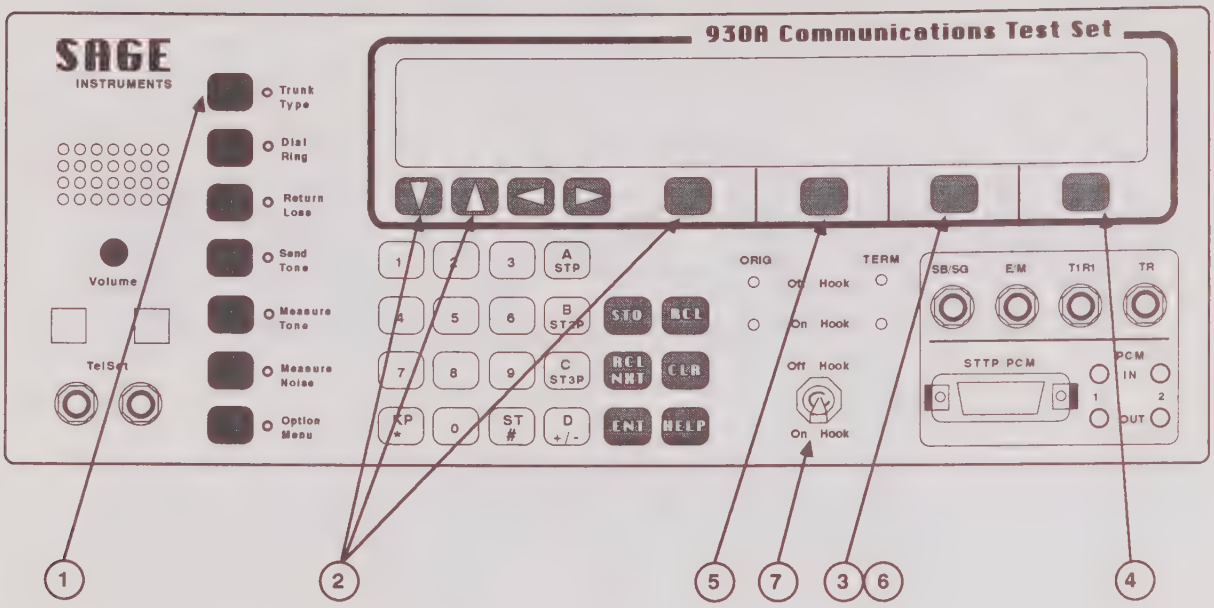


This is the number of milliseconds the 930A will remain Off-Hook during a wink. The range of permissible values lies between 35 and 995 msecs. The factory set default value is 150 msecs. The accuracy is +/- 10 msecs. and the resolution is 10 msecs.



Input from the numeric keypad is treated as a wink period.

Pressing ENTER or any Softkey locks in the displayed wink value and Exits to the Option Menu.



To select SF Supervision Trunk Type:

1. Press the TRUNK TYPE function key.
2. Press Softkey 1 or use the UP/DOWN arrow keys to select the display entitled "OPTIONAL TYPES".
3. Press Softkey 3 labeled "SF" to select SF Supervision.
4. Press Softkey 4 to select the correct impedance (usually 600)
5. Press Softkey 2 to send on Tip/Ring or Tip1/Ring1.
6. Press Softkey 3 to select either BRIDGE or TERMinate operation.
7. Use the Switchhook to go "Off Hook".

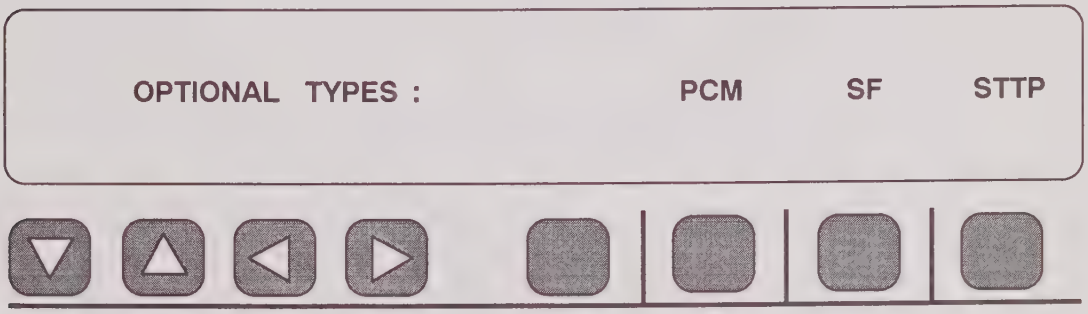
SF TRUNK TYPE SELECTION
FIGURE 4-2

4-3 SF SUPERVISION (OPTION 930A-02)

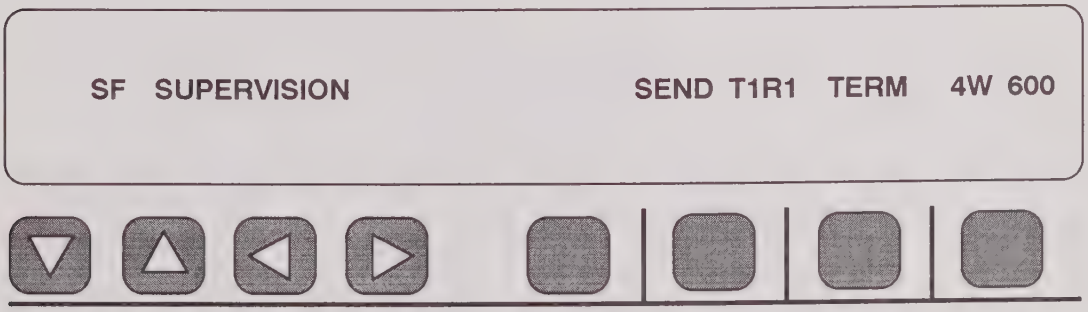
If Option 930A-02 SF SUPERVISION has been installed in the Model 930A, then this optional trunk type can be accessed under the TRUNK TYPE key.

Press the Trunk Type function key to display the currently selected Trunk Type.

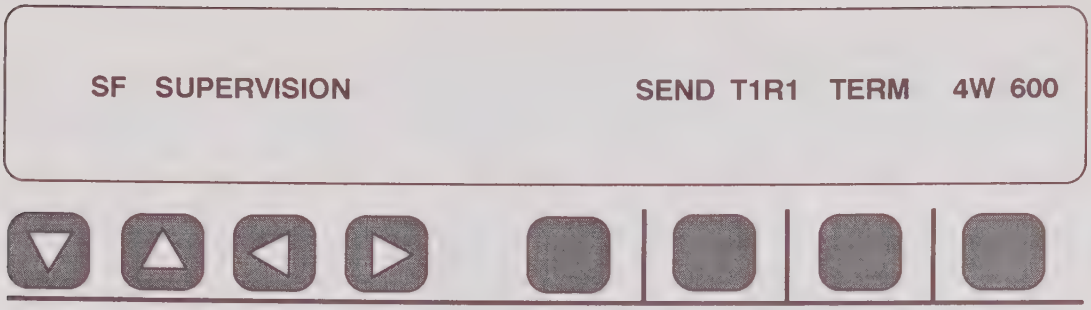
Use the UP/DOWN arrow keys to page through the available displays until the following display appears:



Press Softkey 3 (labeled "SF" above) to enter the SF supervision trunk type and the 930A display will look somewhat like the following:



Single Frequency (SF) supervision sends a 2604 Hz tone to indicate an On-Hook condition. It is inherently a 4-wire trunk type and is now mainly used on special service trunks in the U.S., having been largely displaced in the AT&T message network by CCIS signaling.



Within this display the operation of the front panel keys is as follows:

The Cursor keys and Numeric keypad are inactive.

Softkey 2 toggles the Send direction between TR and T1R1.

Softkey 3 toggles between BRIDGE (Monitor) and TERM (Simulate).

Softkey 4 is a wheel which allows the user to choose 150, 600, 900, or 1200 ohm transmit and receive impedances.

In practice, the impedance selected will most often be 600 ohms which is the typical 4-wire line impedance for analog transmission.

The Model 930A does not presently support 2-Wire SF systems which use 2 tones (2404 and 2604 Hz for example) nor can it be used to provide SF supervision on PCM systems at present. The SF option in the 930A does not support FXS/FXO supervision on SF trunks either. Future enhancements to the 930A may include these capabilities.

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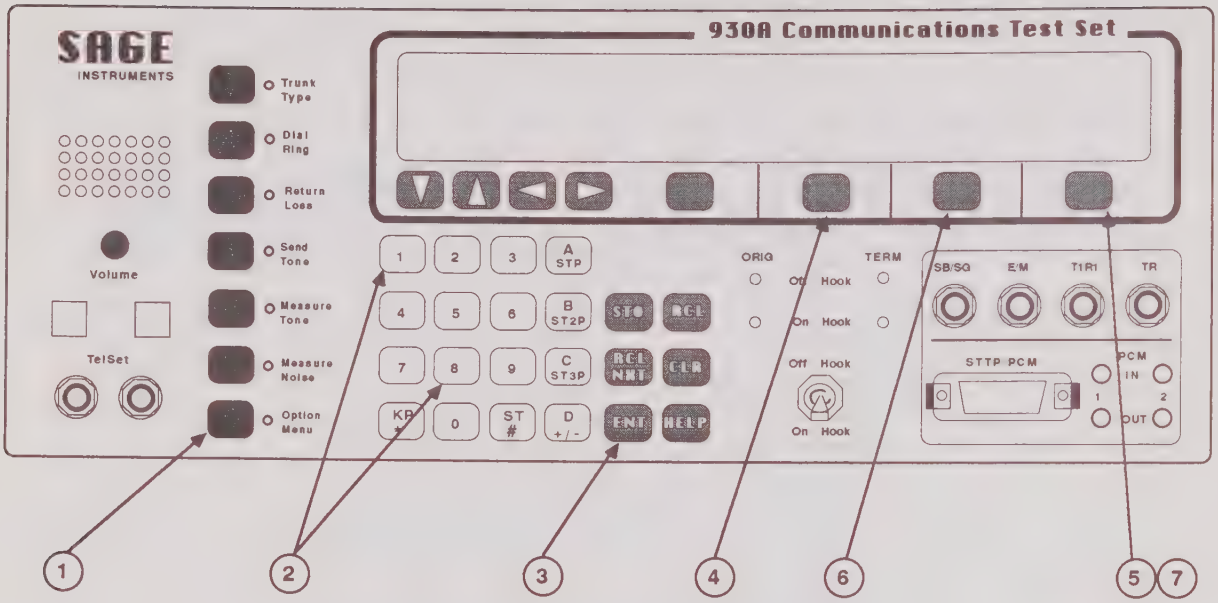


To select the P/AR measurement option:

1. Press the OPTION MENU key.
2. Use the numeric keypad to enter the number 18.
3. Press the ENT(Enter) key to complete the numeric entry.
4. Press Softkey 2 (SEND) if the Transmit level is to be changed, or to send the P/AR signal on a 2-wire circuit.
5. Press Softkey 4 (EXIT) to stop test and return to main menu.
6. Press Softkey 3 (MEASURE) to send P/AR waveform and measure received P/AR on 4-wire circuits.
7. Press Softkey 4 to EXIT from the menu option and stop testing.

P/AR MEASUREMENT OPTION
FIGURE 4-3

4-4 PEAK TO AVERAGE RATIO (P/AR) (OPTION 930A-06)

This optional feature (Option 930A-06) enables the Model 930A to measure P/AR values over a 0 to 120 unit range. The peak-to-average ratio provides a measure of the channel dispersion (amplitude spreads over time) due to transmission impairments. The P/AR signal consists of 16 non-harmonically related tones with a spectral content which approximates a data signal. By measuring the peak-to-average ratio of the received signal, a measure of the dispersion is obtained. By comparing P/AR readings over a period of time, deterioration of a channel can be determined.

P/AR readings are a Figure of Merit rating of the quality of a channel and are directly related to the attenuation distortion, phase distortion, return loss and noise. The P/AR measurement is therefore sensitive to envelope delay distortion, noise, bandwidth reduction, gain ripples, nonlinearities such as compression and clipping, and other impairments.

If the P/AR signal were received over a perfect channel entirely undistorted, the P/AR reading would be 100. A P/AR reading of 85 would indicate a 15 percent reduction in the peak-to-average ratio.

P/AR measurement provides no clues as to the nature of a fault condition in any single case. It is a figure of merit and as such is useful only when compared to previous readings. When a channel is suspect, however, a P/AR reading can be quickly compared to the benchmark value. If the reading deviates more than +/- 4 P/AR units from the benchmark then some channel characteristic (i.e., bandwidth, phase or amplitude distortion, etc.) has changed significantly. The value of the P/AR measurement is that it can be used to quickly determine the worst direction of transmission (near to far or far to near). The parameters of the worst transmission direction can be measured first since it is most probable that the trouble lies in that direction.

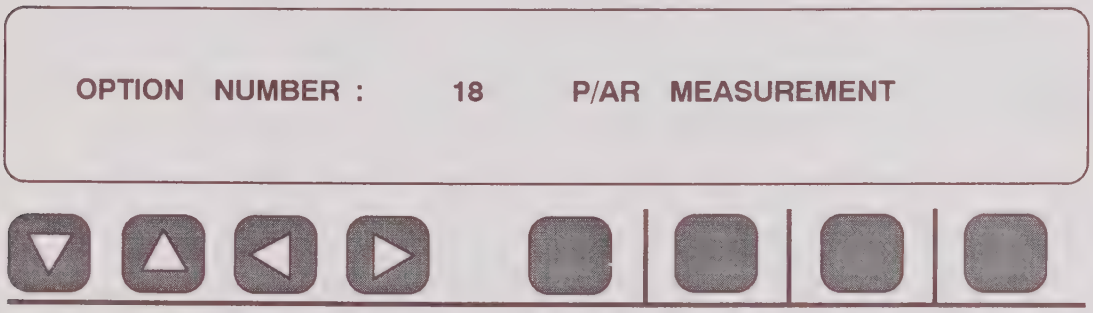
When Option 930A-06 has been installed the user can access P/AR measurement under Menu Option Number 18.

To set up and operate the Model 930A for P/AR measurements perform the following steps:

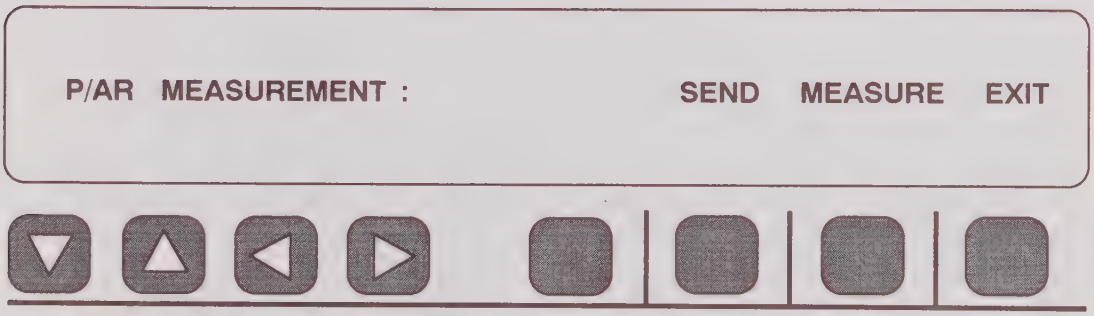
Press the OPTION MENU Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 18: P/AR MEASUREMENT.

The Model 930A display will appear as shown below:

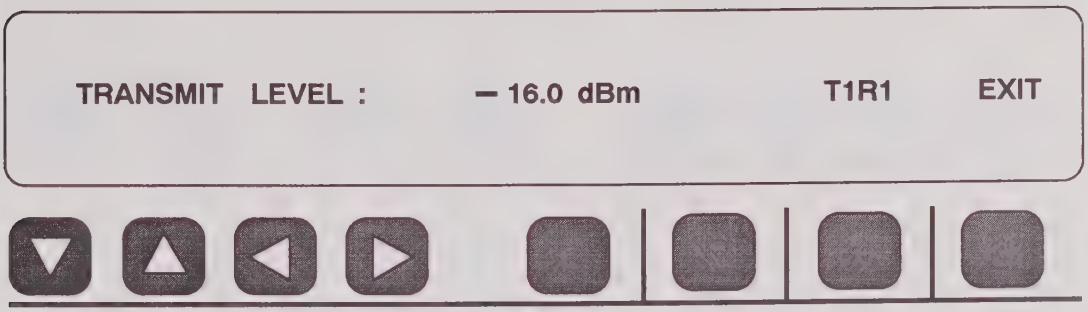


Pressing any Softkey will enter the menu option and the display will become:

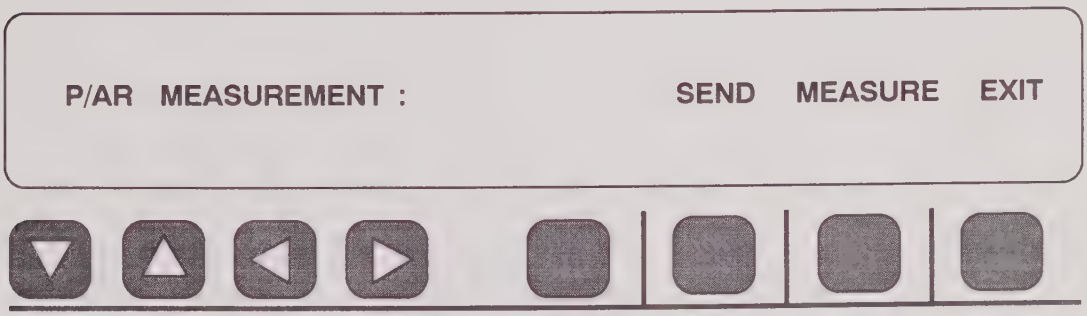


Softkey 2 controls both the set-up of the P/AR transmitter level and sends P/AR signal on a 2-Wire circuit. The set-ups are retained in non-volatile memory and need not be accessed every time a measurement is made unless the level is to be changed.

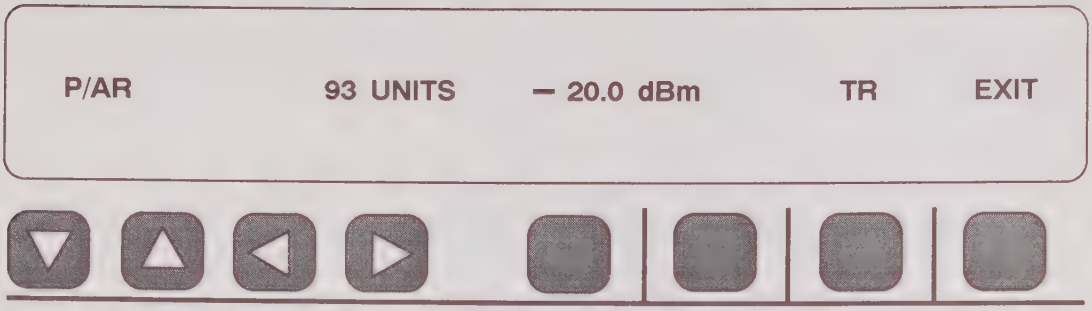
Pressing Softkey 2 (SEND) brings up the P/AR transmit level display. A sample of the SEND display is shown below:



The test set at the far end of the circuit would receive and display the P/AR measurement. The user should not transmit at levels above -13 dBm relative to the 0dB TLP to prevent adjacent channel interference. Select the desired level using the numeric keypad and complete the data entry by pressing the ENTER key. Pressing Softkey 4 (labeled EXIT) in the above display turns off the transmitter if the 930A is set for operation on a 2-wire trunk and returns to the main P/AR display as shown below:



Once the P/AR transmitter level has been set, or turned off as appropriate, the operator may begin sending and receiving the P/AR waveform on a 4-wire circuit or receiving P/AR on a 2-wire circuit by pressing Softkey 3 (labeled MEASURE) in the above display. Pressing Softkey 3 brings up the P/AR measurement display. A typical example of a P/AR measurement display is shown on the following page.



It is assumed that prior to attempting to make a P/AR measurement on a circuit, the operator has selected the appropriate Trunk Type as outlined in Section 3-6. The Model 930A is capable of making P/AR measurements on 2 and 4-wire metallic circuits and T-1 Carrier channels (optional).

It is important to note that P/AR measurements are end-to-end measurements. On 2-wire circuits one end transmits and the other receives. On 4-wire circuits simultaneous transmitting and receiving is possible. When measuring P/AR on 2-wire circuits one of the test sets must have it's transmitter turned off and act as a receiver only.

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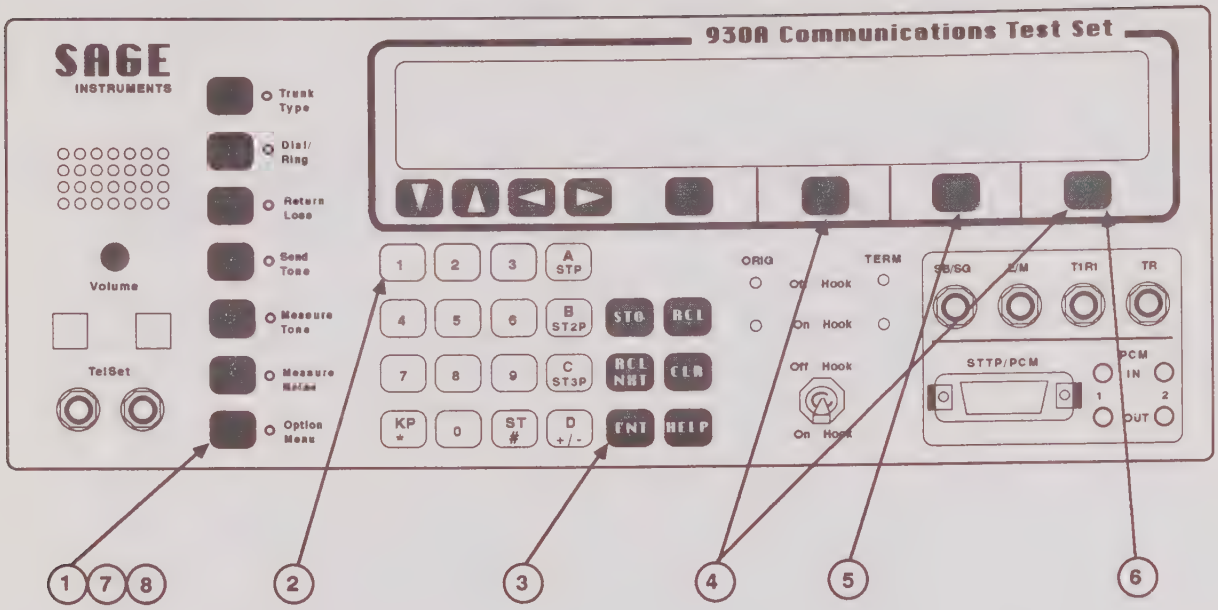


To select the 3-Level Impulse Noise/Hits measurement:

1. Press the OPTION MENU function key.
2. Use the numeric keypad to enter the number 11.
3. Press the ENT(Enter) key to complete the numeric entry.
4. Press Softkey 2 to select DEFAULT settings for Impulse Noise and Hits parameters or Softkey 4 to change the default settings.
5. Press Softkey 3 to enter the measurement display.
6. Press Softkey 4 labeled START to begin measurements.
7. Press the OPTION MENU function key to stop testing.
8. Press the OPTION MENU key again to exit to the main menu.

3-LEVEL IMPULSE NOISE OPTION
FIGURE 4-4

4-5 3-LEVEL IMPULSE NOISE (OPTION 930A-07)

This optional feature (Option 930A-07), when installed in the Model 930A, provides a very important data transmission parameter measurement. The 3-Level Impulse Noise measurement is set up and operated from Menu Option 11. The following step-by-step instructions demonstrate the set-up and measurement procedure. Remember to set up the correct Trunk Type as outlined in Section 3-6 before proceeding.

To begin:

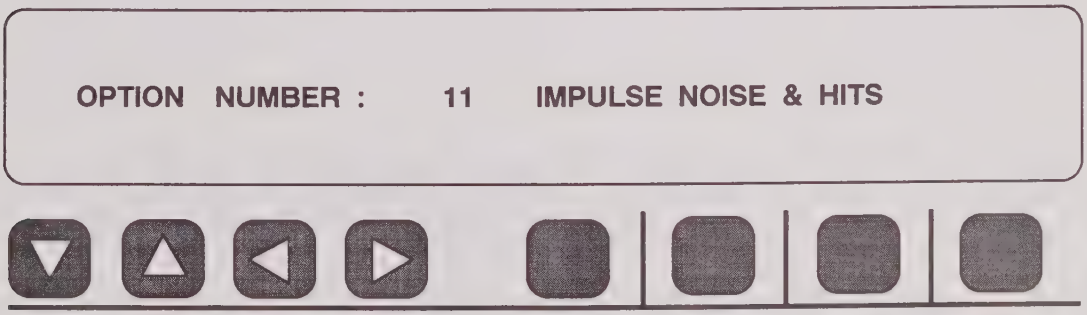
Press the OPTION MENU

function key.

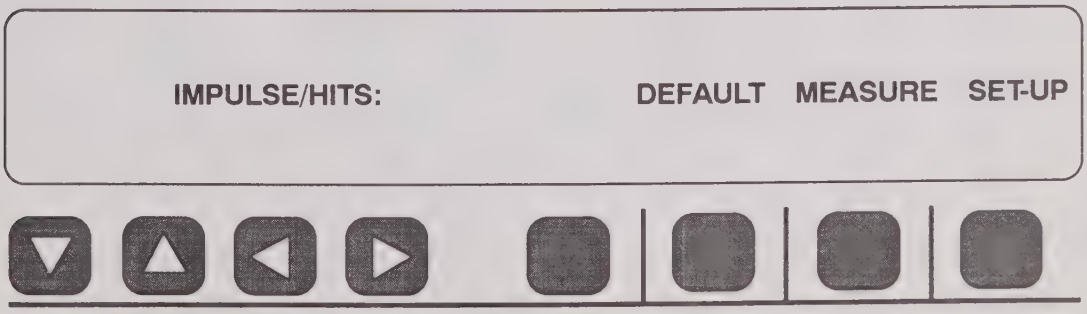
Use the UP/DOWN arrow keys to

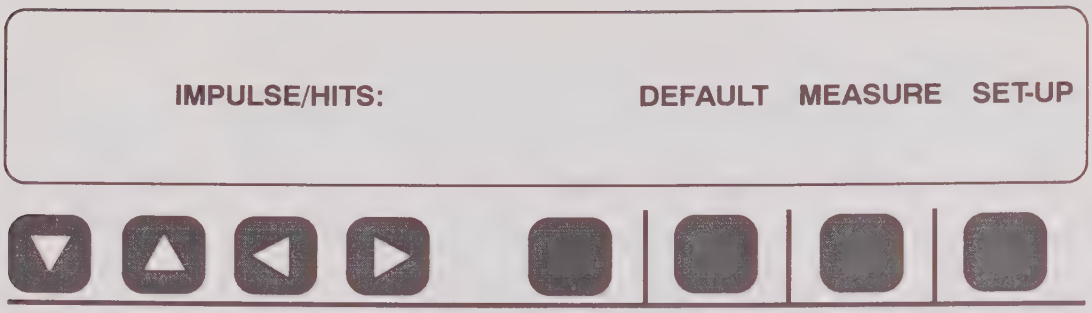
to select Menu Option 11, IMPULSE NOISE & HITS.

The Model 930A display will appear as:



Pressing any Softkey will enter the Menu Option and the display will then show the following:



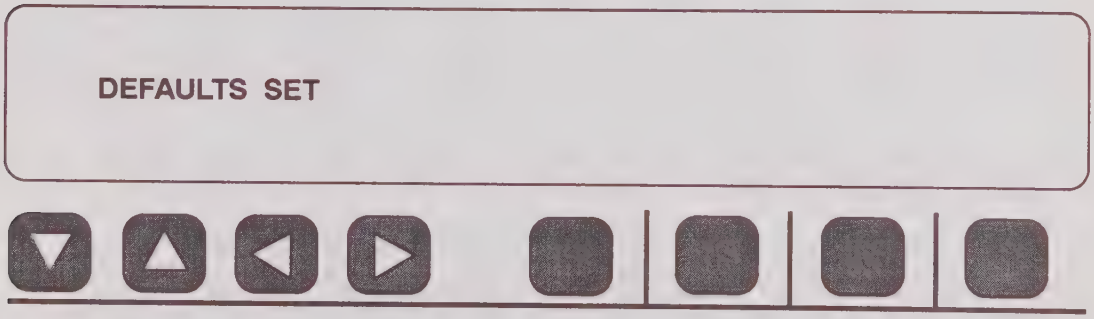


In this section only the 3-Level Impulse Noise measurements will be described. The measurement of Phase Hits, Gain Hits and Dropouts is described in Section 4-11 since this added capability is obtained by purchasing Option 930A-18 in addition to Option 930A-07.

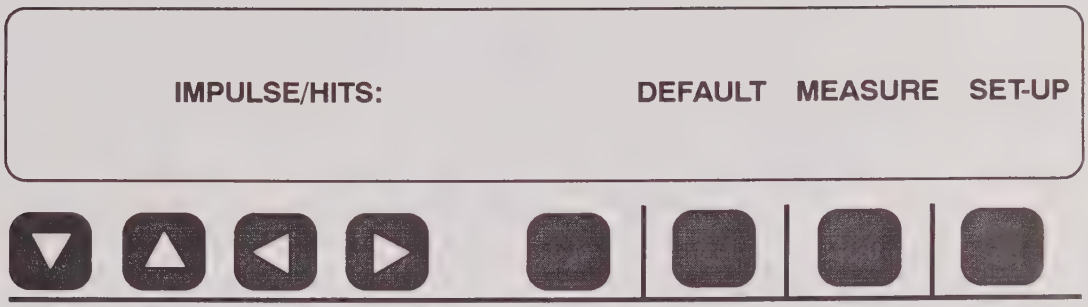
The above display offers three choices: Choosing the DEFAULT test parameters, Begin Measuring, or manually setting up the test parameters.

Pressing Softkey 2 labeled "DEFAULT" will set the correct default test parameters for Impulse Noise and Hits measurements on the trunk type selected. The default values for Impulse Noise measurement are taken from AT&T published specifications for short haul (less than 500 mile length) Voiceband Data circuits. The default values include the fact that Impulse Noise is usually measured with the holding tone present. The tone is notched out using a C-Notch filter.

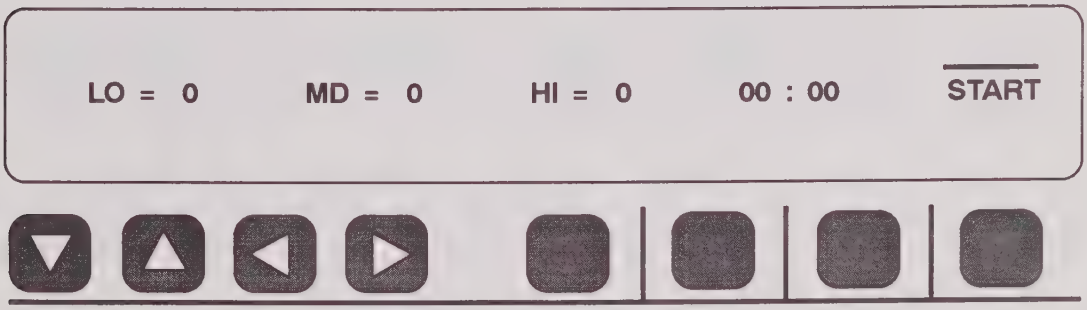
If Softkey 2 is pressed the 930A display will momentarily show:



The display will then return to the main display as shown on the next page.

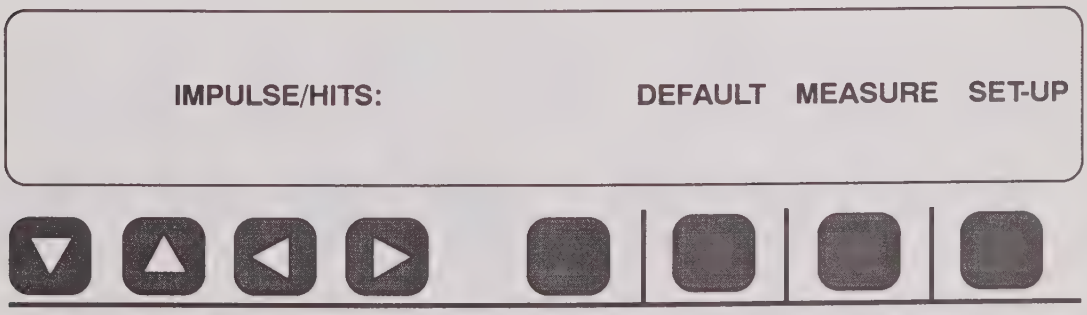


At this point the user would press Softkey 3 labeled "MEASURE" and the 930A display would appear as:



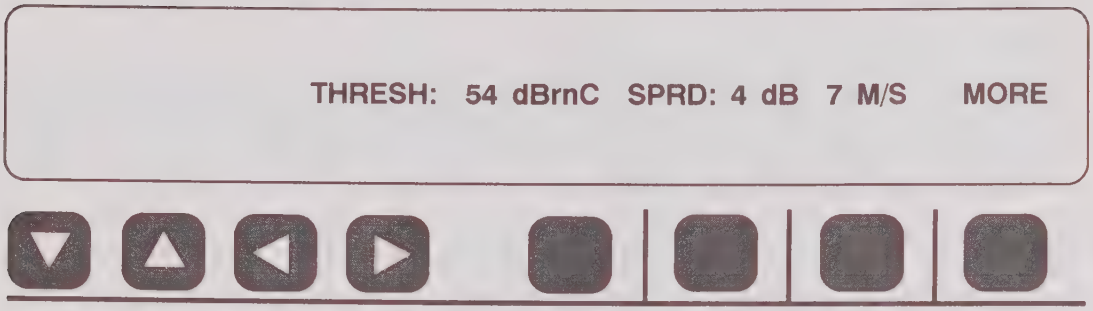
Pressing Softkey 4 labeled "START" would cause the 930A to begin measurements.

If the user desires to use test parameters other than the factory defaults then it is necessary to go through the set-up procedure. The main display is repeated below for example purposes:



For purposes of example, this step-by-step procedure will assume that the test parameters have not yet been set up and it is **not** desired to use the defaults.

Press Softkey 4, labeled "SET-UP",
and the display will appear as follows:

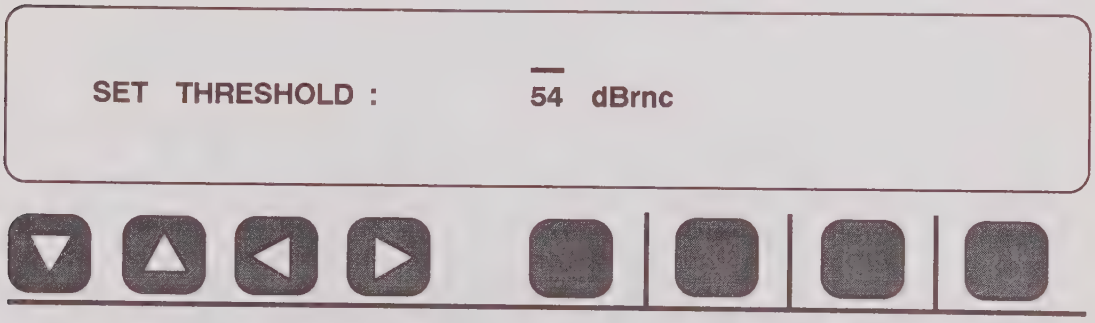


This display enables the user to select either the default values of the 3-Level Impulse Noise/Hits measurement or manually enter the Impulse Noise or Hits parameter values. In this section we are concerned only with setting the Impulse Noise parameters.

There are four Impulse Noise parameters which can be changed from their default values. The user may change any or all of them by first selecting them with the appropriate Softkey.

Suppose it is desired to change all of the measurement parameters beginning with the impulse noise threshold. To accomplish this, perform the following steps:

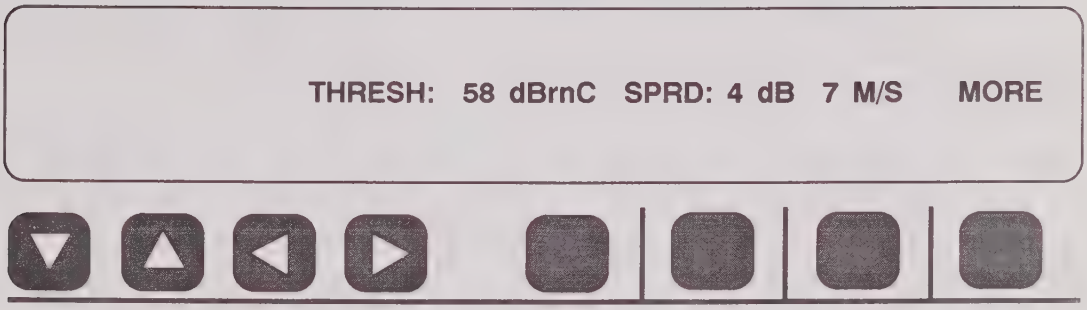
Press Softkey 1 and the 930A display will change to:



The range of threshold settings permitted for the lowest threshold is 30 to 106 dBrnC, assuming the spread between thresholds is 2 dB. No threshold can be higher than 110 dBrnC, so a wider spread creates a lower limit for the initial threshold.

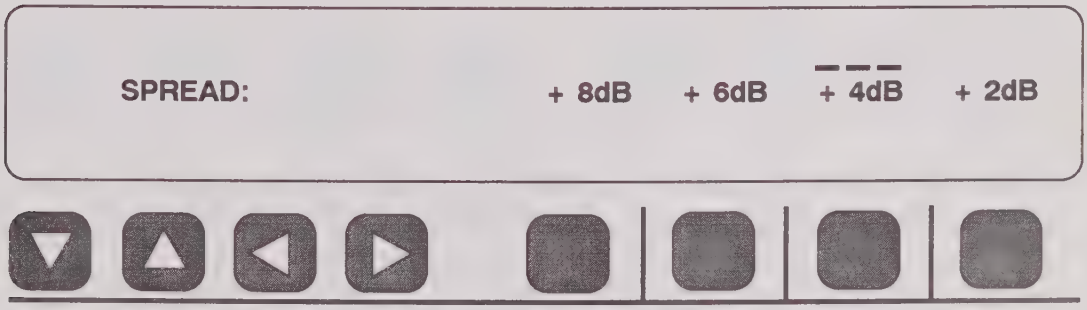
Suppose it is desired to have 58 dBrnC as the lower threshold. To change to this value perform the following steps:

Press [5] and [8] and then [ENT]
and the 930A display will show:

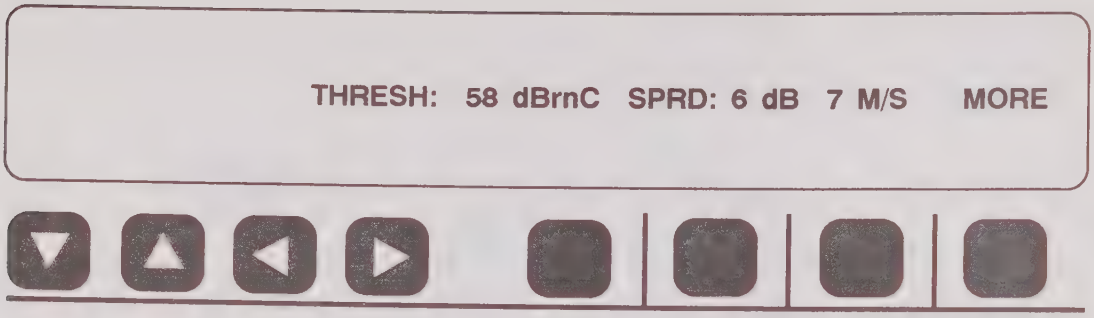


Note that the new threshold value is now displayed and the impulse noise counters are now set to 58 dBrnC, 62 dBrnC, and 66 dBrnC since the spread is still 4 dB.

Next, to change the size of the spread between the Low, Mid, and High impulse noise measurement counters, press Softkey 2 (under SPRD: N dB) and the 930A display will change to:



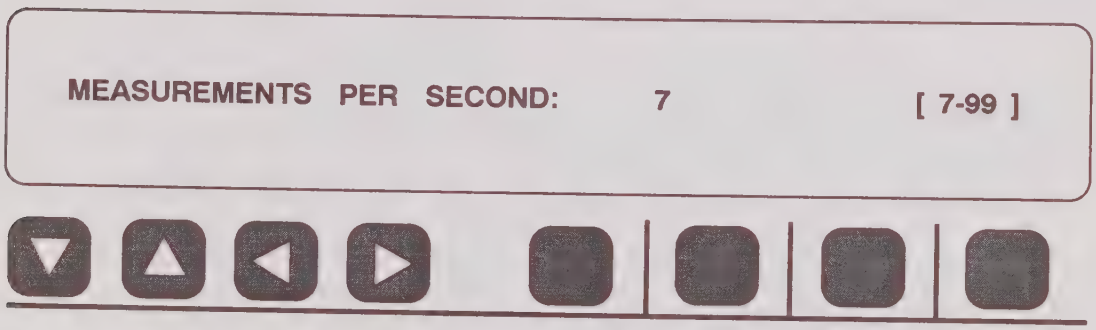
The flashing cursor appears over the currently selected step size (+4 dB in this example). The step size choices range from + 8 dB to + 2 dB in 2 dB increments and each choice appears directly above it's associated Softkey. To choose, for example, a step size of + 6dB instead of the + 4 dB value, simply press Softkey 2 (under the + 6dB above) and the 930A display will change to:



Note that the Spread is now 6dB and the counter thresholds will now be set at 58 dBrnC, 64 dBrnC, and 70 dBrnC.

Next, the number of measurements per second which the set makes will be changed. The standard value is 7 measurements per second but other common values are 8 measurements per second and what is called a "channel limited" measurement. To change the number of measurements per second, do the following:

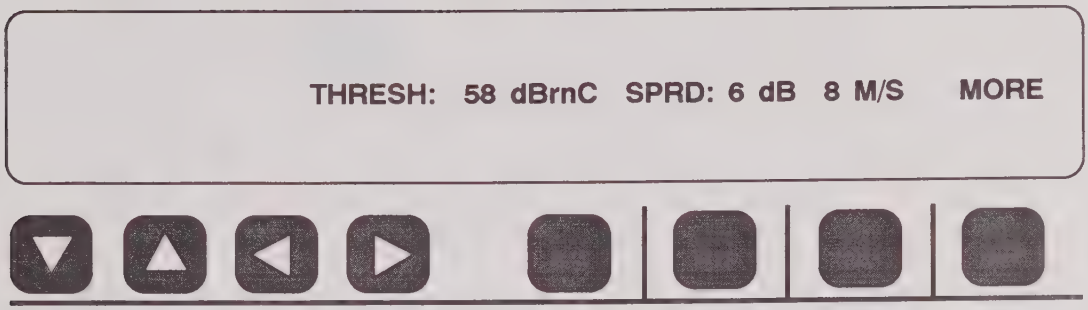
Press Softkey 3 and the 930A display will change to:



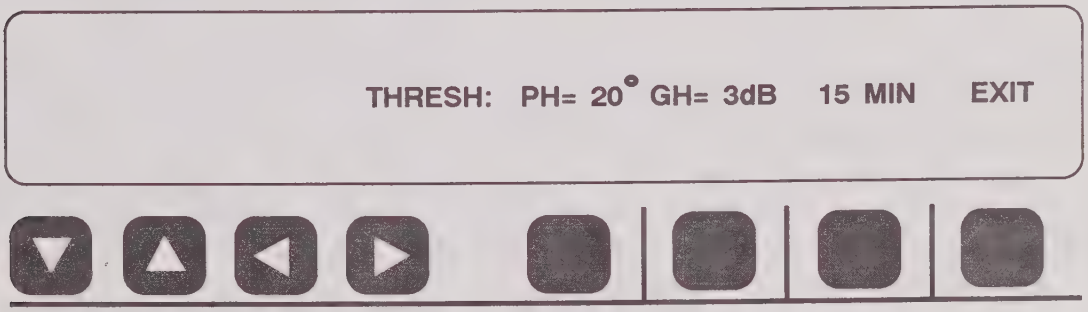
Note that the acceptable values range from 7 measurements per second to 99 measurements per second. If, for example, it is desired to set in a value of 8 measurements per second, then do the following:

Press [8] and then [ENT]

and the 930A display will change to:



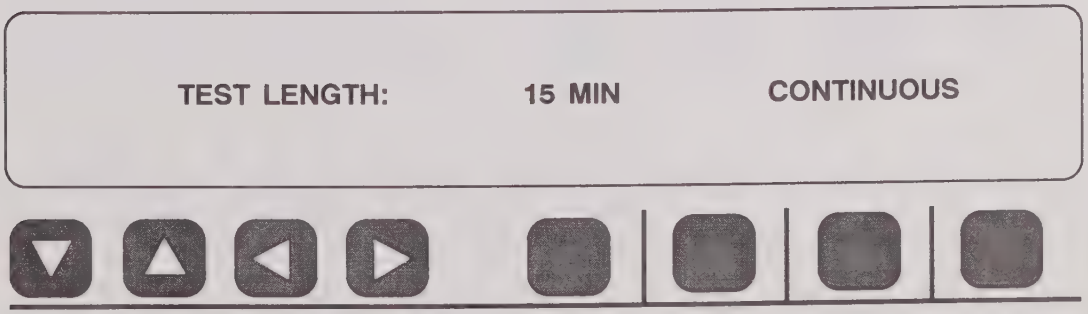
Next, to change the measurement time period, press Softkey 4 labeled "MORE" and the 930A display will show:



The Phase and Gain Hit Thresholds will be discussed in Section 4-11 and so we go directly to the measurement interval.

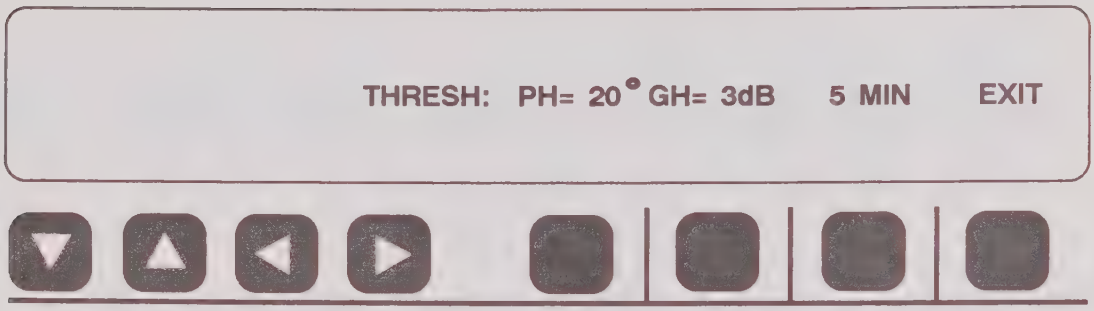
The standard value used is 15 minutes, however, the Model 930A can make timed measurements of impulse noise from 1 minute duration to 99 minutes duration or it can be set to continuously measure.

Suppose for this example that a 5 minute test length is desired. Press Softkey 3 and the 930A display becomes:



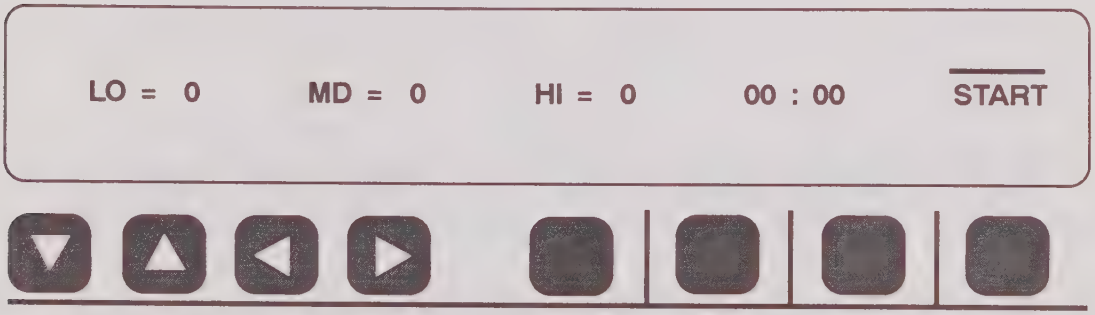
Press [5] and then [ENT]

and the 930A display changes to:



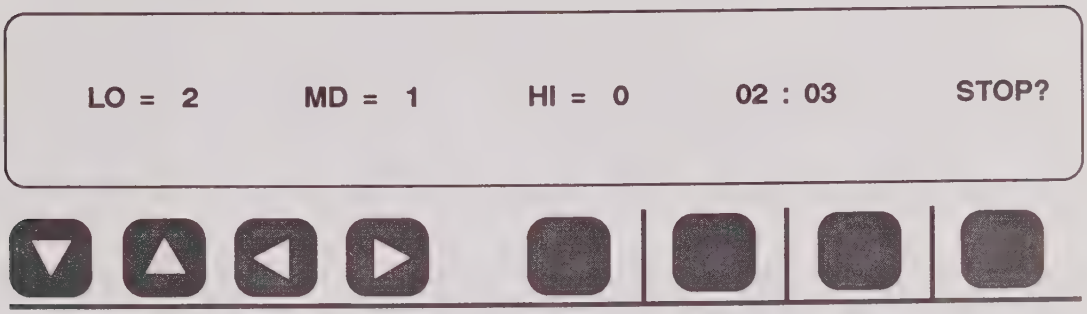
All of the Impulse Noise measurement parameters have now been changed. The user is free to select other values within the acceptable ranges given for each parameter. This example was intended only to show the method.

Once the user has set-up the Model 930A, pressing Softkey 4 labeled "EXIT" in the above display will cause the 930A to immediately go to the measurement display shown below:



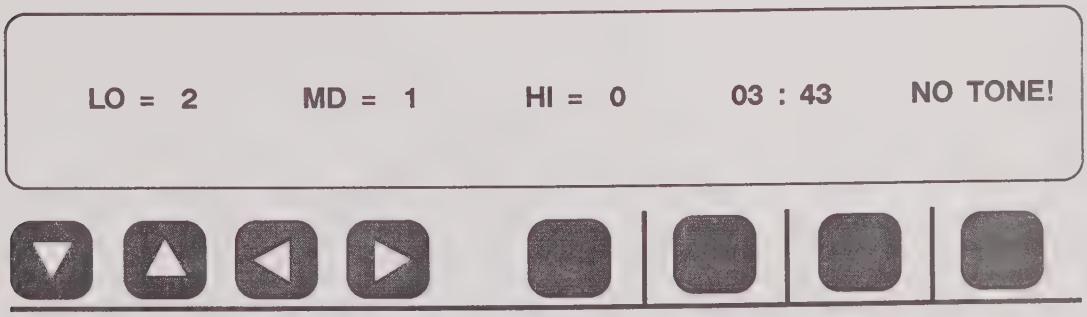
Pressing Softkey 4 now labeled "START" will cause the 930A to begin measurements.

After some time has elapsed (remember that this example has set a 5 minute measurement time) a typical display might appear as:



This display shows that after 2 minutes and 3 seconds of testing, there have been 2 impulse noise bursts that have exceeded the 58 dBrnC threshold, 1 that has exceeded the 64 dBrnC threshold and none that has exceeded the 70 dBrnC threshold. This test would continue until 5 minutes had elapsed and then stop (Time was set to 5 minutes in this example). The user may choose to stop the test at any time by pressing the OPTION MENU function key. The impulse counters have maximum values of 9999 impulses.

If the test is to be performed with holding tone over a loopback circuit, the 930A should be set to send 1004 Hz at -13.0 dBm using the SEND TONE function. The words "NO TONE!" will appear above Softkey 4 if the holding tone drops below -40.0 dBm at any time during the test, as shown below:



The default value of low threshold used by the 930A is 54 dBrnC0 which is the setting for voice frequency metallic cable facilities less than 500 miles in length. This threshold assumes the use of a -13 dBm0 holding tone.

If the user has selected the PCM or T-1 Carrier trunk interface, then the 930A will select 67 dBrnC0 as its low threshold when DEFAULT is pressed since this is the correct low threshold on t-Carrier circuits.

Other commonly used low thresholds are: 59 dBrnC0 for PBX tie trunks and 67 dBrnC0 for mixed metallic and T-1 carrier facilities less than 500 miles long. So, even though the measurement may be made on the metallic end of a circuit, the user must still change the low threshold to 67 dBrnC if any part of the end-to-end circuit goes over T-1 carrier facility.

The maximum allowable impulse counts over a 15 minute period relate to the threshold and step size and are:

Threshold	< 15 counts
Threshold + 4 dB	< 9 counts
Threshold + 8 dB	< 5 counts

The overall end-to-end low threshold at the customer premises is usually 71 dBrnC0. The end link threshold alone is usually 67 dBrnC0. The mid link thresholds are based upon mileage and range from 54 to 73 dBrnC0.

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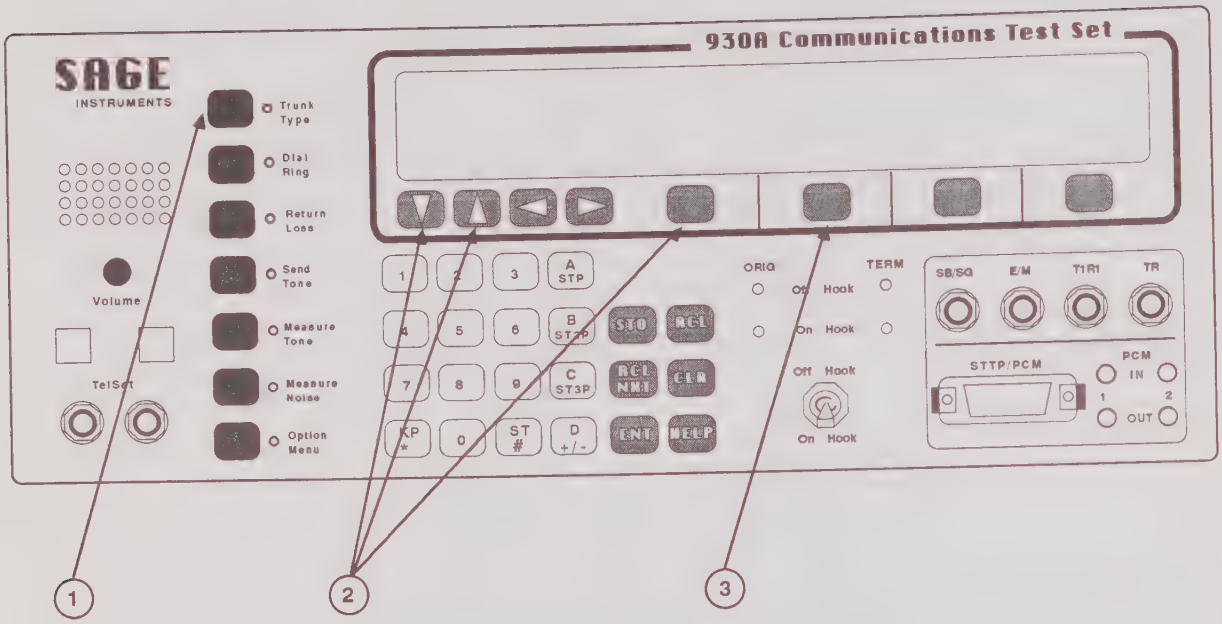


To select T-1 (DS-1) PCM Trunk Type:

1. Press the TRUNK TYPE function key.
2. Use the UP/DOWN arrow keys or Softkey 1 to select the display entitled "OPTIONAL TYPES".
3. Press Softkey 2 labeled "PCM".
4. Refer to Section 4-6.2 for operation of front panel keys in PCM.

PCM TRUNK TYPE SELECTION
FIGURE 4-5

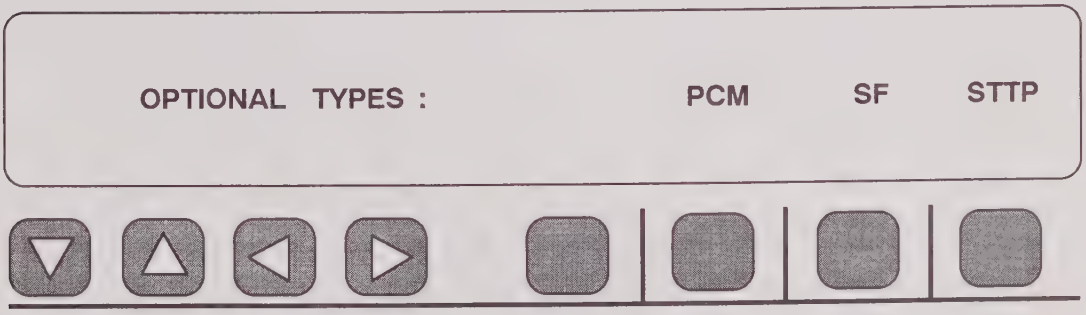
4-6 PCM TRUNK TYPE (OPTION 930A-08 OR -09)

This section of the manual describes the operation of the 930A when either Option 930A-08 (PCM Channel Access) or Option 930A-09 (Dual Direction Drop and Insert) has been installed in the unit. **NOTE:** If option 930A-17 (No metallic interface) has been ordered, pressing the Trunk Type key leads immediately to the primary PCM display (See p. 4-69 for an example).

To begin, the operator must select the PCM Trunk Type as follows:

Press the Trunk Type function key to display the currently selected Trunk Type.

Use the UP/DOWN arrow keys to page through the available displays until the following display appears:



Pressing the Up Arrow or Softkey 1 will page through the trunk types starting at Loop Supervision.

Pressing the Down Arrow key will page backward through the trunk types from E&M type V.

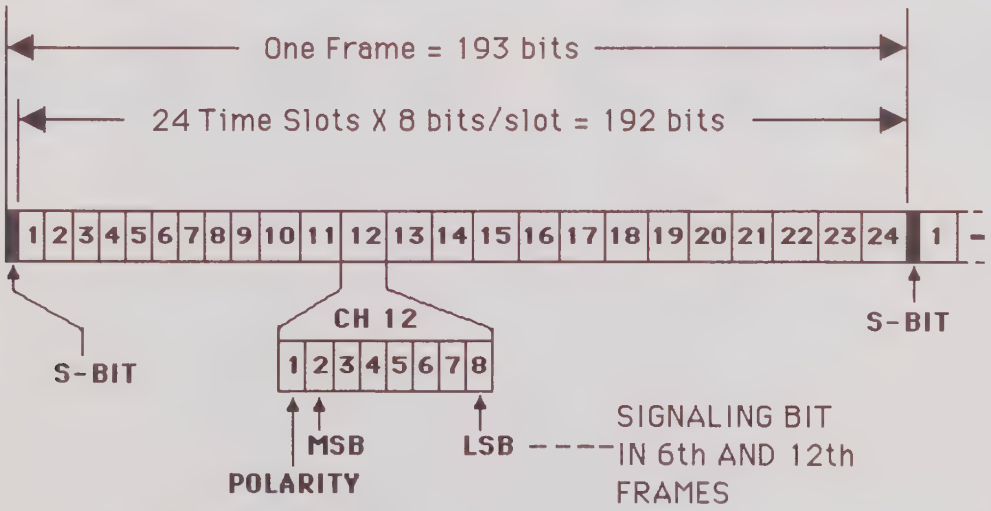
Press Softkey 2 to enter PCM (if the option has been installed).

Softkey 3 is for SF supervision (if installed refer to Section 4-3) and Softkey 4 activates the STTP interface if installed.

Before describing the operation of the 930A front panel keys and how the 930A can be used to test PCM trunks, it is worthwhile to first review some of the fundamentals of DS-1 (T-1) PCM transmission.

4-6.1 DS-1 PCM TRANSMISSION

The Model 930A, with either Option 930A-08 or -09 installed, will work with DS-1 (T-1) systems as well as metallic trunks. The T-1 Carrier system, introduced by AT&T in 1962, is a Time Division Multiplex (TDM) system that places 24 trunk circuits onto a single span line. Each individual trunk circuit consists of a Pulse Code Modulated (PCM) representation of the information which was on the message circuit input (normally speech). The input is sampled at an 8KHz rate and encoded into PCM using an 8 bit code which works out to the well known 64 Kbps data rate for an individual PCM channel. Since there are 24 channels, plus another 8 Kbps of overhead framing bits, the overall T-1 rate can be seen to be 1.544 Mbps. The T-1 system organizes these channels in a continuous bit stream which uses the additional or overhead bits, called Framing bits, to enable receiving equipment to synchronize and recover the information. In order to synchronize the transmission the synch pattern is repeated every twelve frames and this gives rise to the so-called Superframe format. The following diagram illustrates a typical frame of T-1.


One Frame = 193 bits
24 Time Slots X 8 bits/slot = 192 bits
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 1
S-BIT
S-BIT
CH 12
1 2 3 4 5 6 7 8
MSB
LSB
POLARITY
SIGNALING BIT
IN 6th AND 12th
FRAMES

The frame bit, or S-bit, occurs after every 192 information bits. The sync pattern is generated by looking at the S-bits in twelve successive frames. The sync pattern for Superframe format is 100011011100 and repeats every 12 frames.

In addition to the message information which is encoded, the T-1 system also includes supervision information by "robbing" the least significant bit from the sixth and twelfth frames and using these "A" and "B" bits for sending supervision.

The S-bit pattern, in turn, is broken down into two 6 bit long patterns called the Terminal Framing and Signaling Framing patterns.

	S-BIT	
FRAME NUMBER	TERMINAL FRAMING F_T	SIGNALING FRAMING F_S
1	1	-
2	-	0
3	0	-
4	-	0
5	1	-
6	-	1
7	0	-
8	-	1
9	1	-
10	-	1
11	0	-
12	-	0

Once the terminal equipment has acquired frame sync, it is able to identify the individual time slots and this is how the receiving equipment is able to properly decode the individual messages.

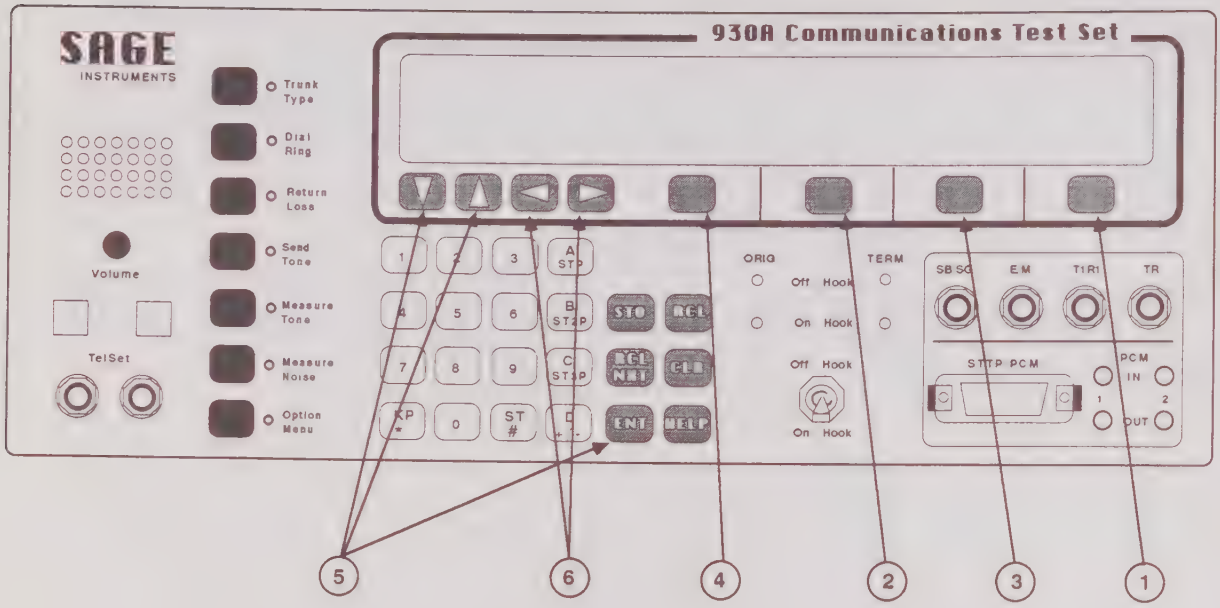
There are several channel numbering schemes in use and they are based primarily upon the vintage of the digital channel banks which generated them. These equate the time slots to individual channel numbers and it was not always the logical one to one relationship which one might assume. The three common sequences are:

	CHANNEL NUMBERING		
TIME SLOT	PREFERRED SEQUENCE (D3/D4)	D1D SEQUENCE	D2 SEQUENCE
1	1	1	12
2	2	13	13
3	3	2	1
4	4	14	17
5	5	3	5
6	6	15	21
7	7	4	9
8	8	16	15
9	9	5	3
10	10	17	19
11	11	6	7
12	12	18	23
13	13	7	11
14	14	19	14
15	15	8	2
16	16	20	18
17	17	9	6
18	18	21	22
19	19	10	10
20	20	22	16
21	21	11	4
22	22	23	20
23	23	12	8
24	24	24	24

Since there exist many installed channel banks of each type it is necessary for a test set such as the Model 930A to provide access to any of them.

The Model 930A provides access to the channel selected so that VF signals and supervision can be sent and received. In this brief summary of T-1 transmission, the topics of Extended Superframe Format (ESF), Clear Channel Capability (B8ZS), and Common Channel Interoffice Signaling (CCIS) have purposely been left for a future T-1 appendix to this manual, since these topics deserve a more in-depth discussion than is desirable in this Section.

With the conclusion of this brief review of PCM Transmission, the operation of the front panel keys and PCM Trunk testing using the Model 930A can be discussed.



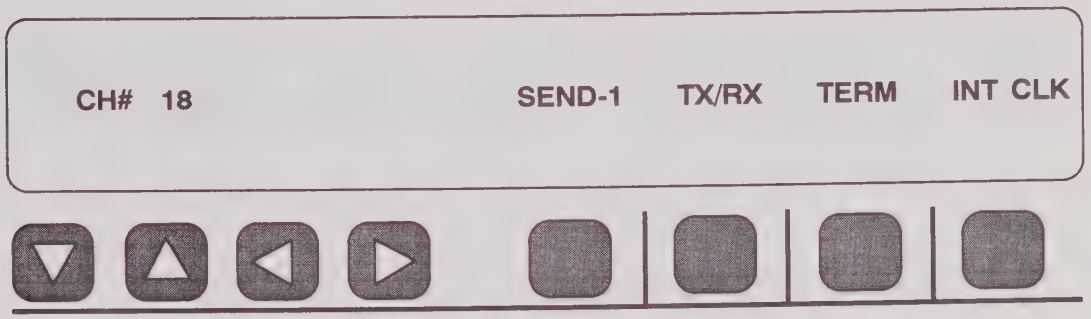
To set up the Primary PCM display after selecting PCM Trunk Type:

1. Press Softkey 4 to select EXTernal Clock when testing on working T-1 spans or select INTernal Clock for out of service testing when the 930A must supply the clock.
2. Press Softkey 2 to select TX/RX mode for single direction testing, THRU mode for monitoring both directions, or D&I for full dual direction drop and insert testing.
3. Press Softkey 3 to select TERMinated operation for testing at the DSX jackfield. Select BRIDGE only if the test set is at a DEMARC point where there are no monitor jacks and it is desired to bridge onto the line and monitor the traffic.
4. Press Softkey 1 to change direction of transmission or reception in the THRU and D&I modes.
5. Use the UP/DOWN arrow keys or the numeric keypad and ENT key to change PCM Channel number from 1 to 24 as desired.
6. Use the Left and Right Arrow keys to access the other PCM parameters such as FXO/FXS supervision, CCIS, and sending Remote Alarm.

PCM PRIMARY DISPLAY SET-UP
FIGURE 4-6

4-6.2 FUNCTION OF FRONT PANEL CONTROLS IN PCM

If either Option 930A-08 (DS-1 PCM Send/Receive) or Option 930A-09 (DS-1 PCM Dual Direction Drop and Insert) has been installed, pressing Softkey 2 (labeled PCM) in the OPTIONAL TRUNK TYPE screen (Refer to Section 4-6) will activate the PCM interface and bring up the primary PCM Option Screen. **NOTE:** If option 930A-17 (No metallic interface) has been ordered, the primary PCM display is accessed simply by pressing the Trunk Type key. A typical example of the primary PCM display is shown below:



"CH#18" indicates that PCM channel 18 has been selected.

"SEND-1" means that the output from the 930A is on the PCM-1 OUT jack.

"TX/RX" means the 930A is in the Send/Receive mode.

"TERM" means that the PCM input is terminated in 100 ohms.

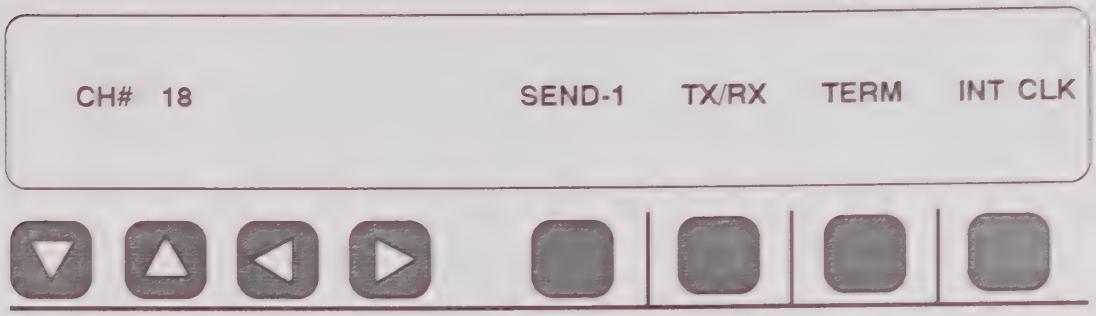
"INT CLK" means that the 930A is supplying clock using its own internal crystal oscillator.

The PCM interface has too many parameters to be set from a single screen, so four screens, accessed through the Left and Right Arrow keys, are used.

1) The PCM Primary Option screen
2) The Signaling screen
3) The Coding and Sequence screen
4) The PCM Diagnostics screen

4-6.2.1 KEY OPERATION IN THE PRIMARY OPTION SCREEN

The example display for the Primary Option Screen in Section 4-6.2 is repeated below:



The functions of the various front panel keys within this screen are

The Up/Down Arrows increment and decrement the PCM Channel Number from 1 to 24.

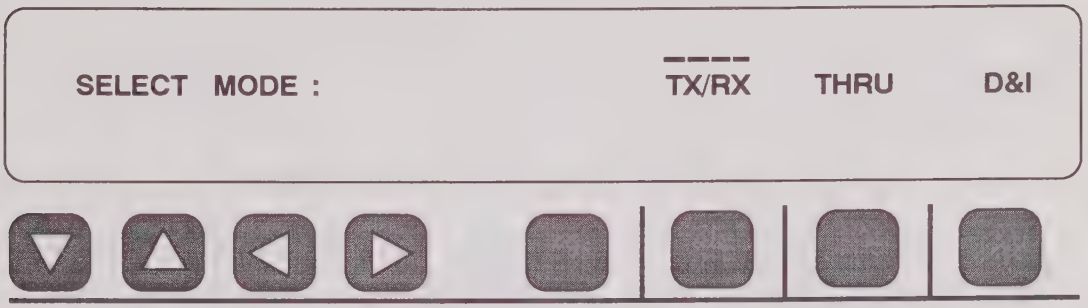
The Right Arrow key advances to the Signaling screen and so on.

The Left Arrow key brings up the PCM Diagnostics display and so on.

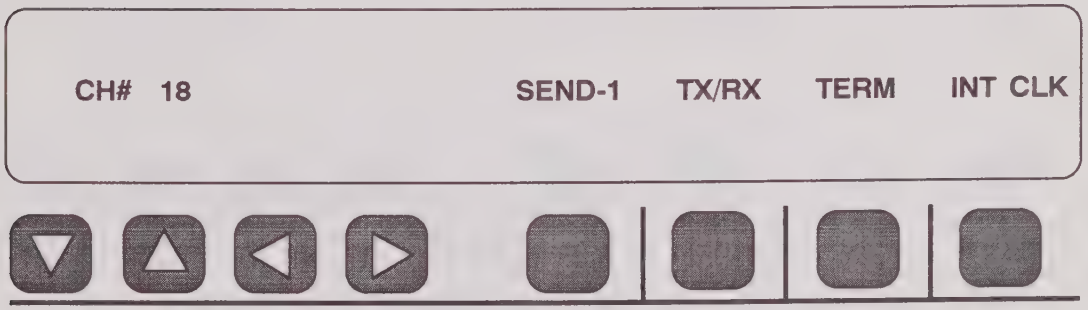
Numeric input is treated as a Channel Number. Any number between 1 and 24 may be entered. Larger numbers will be truncated.

Softkey 1 toggles between SEND-1 and SEND-2 if the 930A is in the THRU or D&I mode. In the TX/RX mode, the Send direction is always SEND-1 and Softkey 1 is inactive.

If option 930A-08 has been ordered, only TX/RX mode is available and Softkey 2 is inactive. With option 930A-09, Softkey 2 selects the basic PCM mode. Pressing it brings up the following display:



Pressing Softkeys 2, 3, or 4 will then select either the TX/RX, THRU, or D&I mode, respectively, and return to the primary screen. Refer to Section 4-6.3 for details on the use of TX/RX, THRU, and D&I. THRU and D&I are part of Option 930A-09.



Softkey 3 toggles between TERM (100 ohms PCM input) and BRIDGE (>1000 ohms impedance).

Softkey 4 toggles between Internal (INT) clock (derived from the 930A internal crystal oscillator) and External (EXT) clock (derived from the T-1 input bit stream). In THRU and D&I modes, External clock is always selected.

Pressing the Right Arrow key will advance to the Supervision screen which is discussed in the next sub-section.

4-6.2.2 KEY OPERATION IN THE SUPERVISION SCREEN

Pressing the RIGHT ARROW KEY while in the primary option screen will bring up the Supervision Screen which has the following appearance:

The default, or "normal" supervision mode in PCM is "LOOP" which also happens to work as the E&M supervision provided by switches on PCM trunks. This mode is shown highlighted in the above display. The front panel keys have the following functions:

The LEFT ARROW key returns to the Primary Options Screen.

The RIGHT ARROW key advances to the Coding and Sequence Screen.

Softkey 1 selects FXS supervision * (Requires Option 930A-25).

Softkey 2 selects FXO supervision * (Requires Option 930A-25).

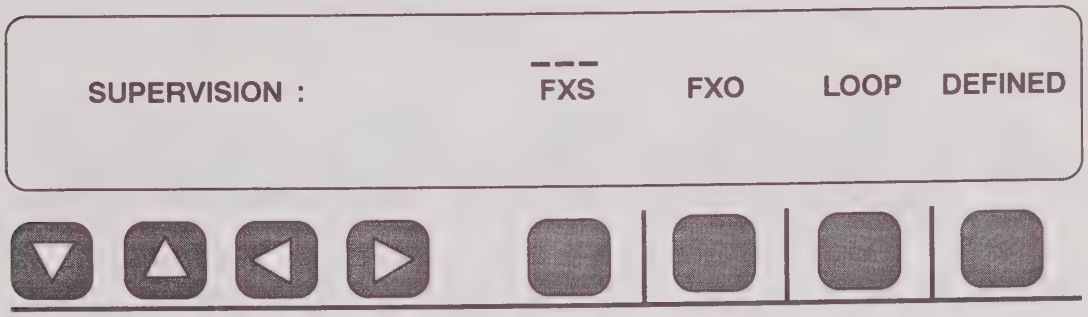
Softkey 3 selects LOOP (E&M) supervision.

Softkey 4 selects User Defined supervision.

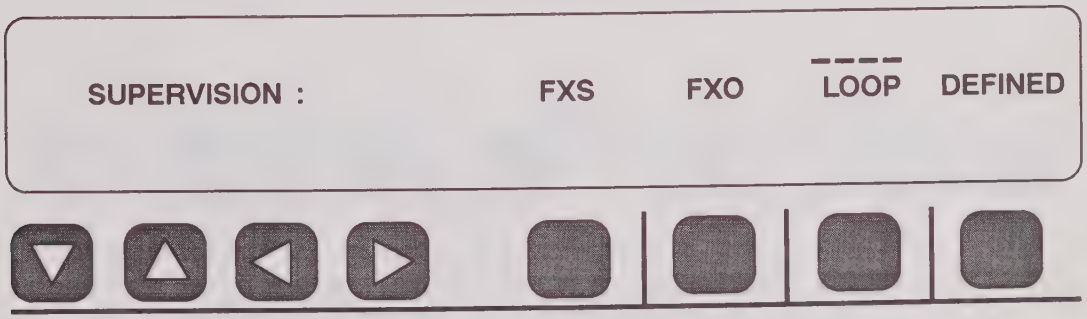
All other keys are inactive.

*** NOTE:** Option 930A-25 is currently useful in the DROP & INSERT and THRU modes. In the TX/RX mode, selecting FXO/FXS will cause the other 23 channels of the T-1 line to go OFF HOOK and Ring.

Two supervision modes, LOOP and USER DEFINED, come with the purchase of Options 930A-08 or 930A-09. The operation of each of these Supervision types is described in this section. To begin, a typical Supervision Screen is shown below.



LOOP supervision causes the 930A to send and receive supervision in the manner most commonly used over PCM circuits. To select LOOP supervision, press Softkey 3 and the above display will change to:

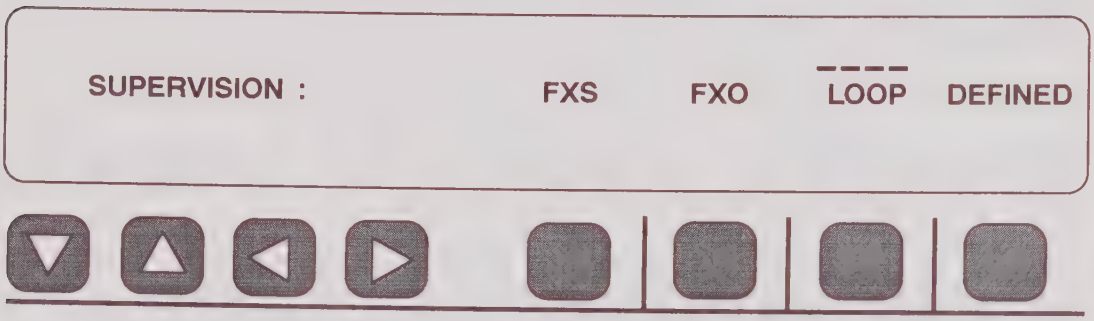


When the Model 930A is On-Hook, it sends the Loop Idle bit pattern (A=0, B=0).

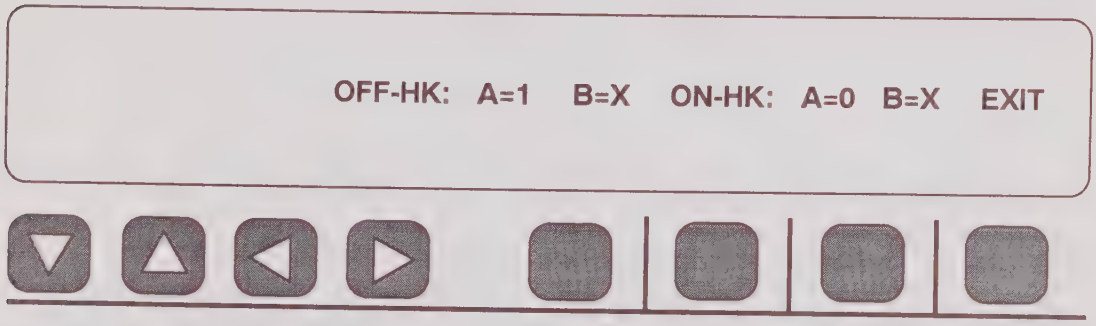
When the Model 930A is Off-Hook, it sends the Loop Closed bit pattern (A=1, B=1).

The Model 930A assumes that the far end is signaling in the same manner. A=0, B=0 is interpreted as On-Hook, and A=1, B=1 is interpreted as Off-Hook.

USER DEFINED supervision provides the user with the ability to define the A and B bit patterns for On and Off-Hook to be whatever is desired.



Pressing Softkey 4 in the above display would cause the Model 930A to select the User Defined supervision mode and the display would immediately change to:

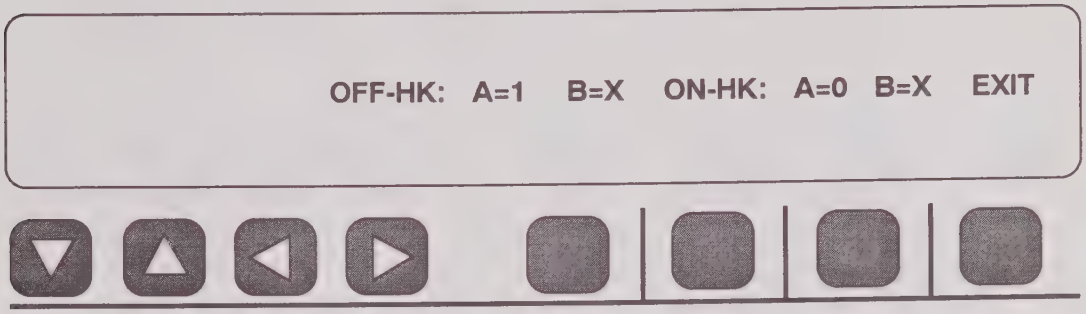


In the above display, the Off-Hook state has been defined as A=1 and the B bit is ignored. The On-Hook state has been defined as A=0 and B bit ignored. Pressing Softkey 1 allows the user to scroll through the various choices of states for the Off-Hook condition. Pressing Softkey 3 scrolls through the choices for the On-Hook state. These conditions are listed below. An X indicates a "Don't Care" or ignored state:

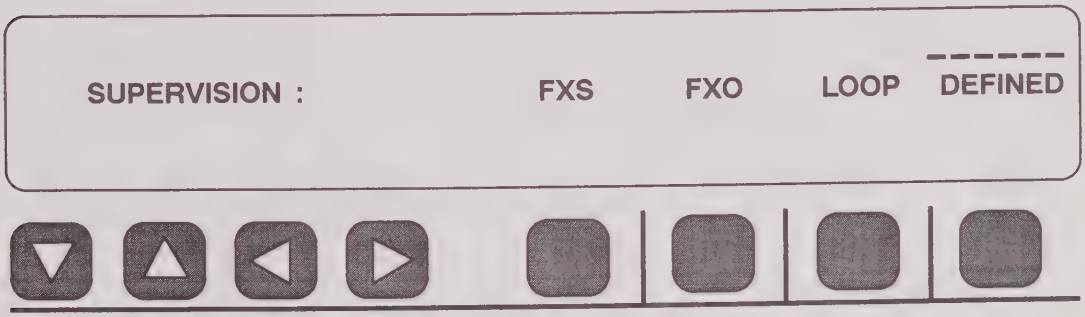
OFF-HOOK	ON-HOOK
A=1, B=X	A=0, B=X
A=X, B=0	A=1, B=X
A=X, B=1	A=X, B=0
A=0, B=0	A=X, B=1
A=1, B=1	A=0, B=0
A=0, B=1	A=1, B=1
A=1, B=0	A=0, B=1
A=0, B=X	A=1, B=0

The 930A sends a "1" for bits marked "X" (don't care)

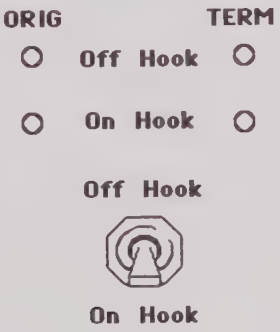
When the user has selected the appropriate supervision condition it is then necessary to return to the Supervision Screen.



Press Softkey 4, labeled EXIT above, and the 930A will accept the displayed bit patterns as correct and exit back to the Supervision Screen as shown below:



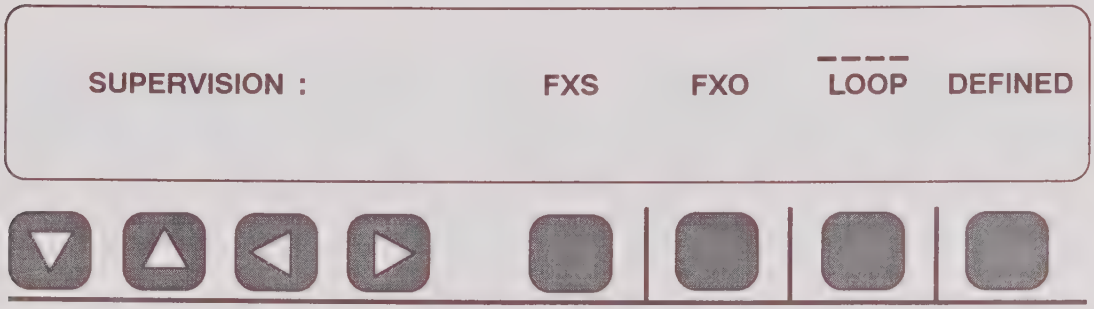
Having selected the appropriate supervision type, the HOOK SWITCH controls the 930A and the status of the originate and terminate ends of the circuit is displayed on the front panel supervision lamps.



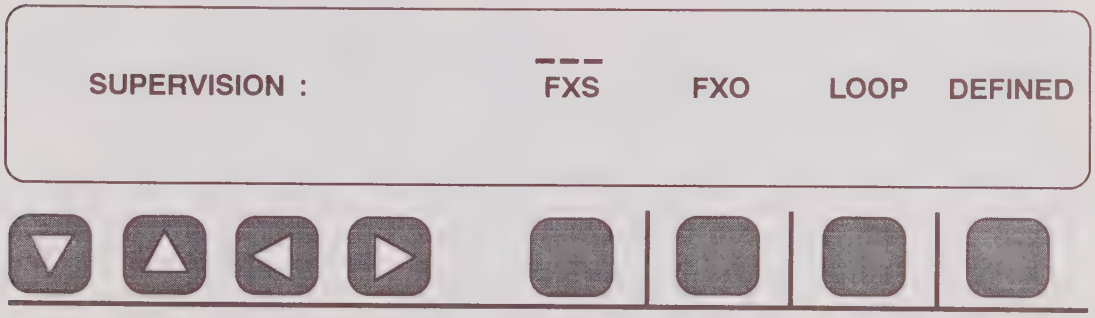
If it is desired to control the A and B bits independently, or to see the status of both bits simultaneously, refer to Section 4-6.5 OPTION NUMBER: 21 TOGGLE A/B BITS.

4-6.2.3 FXS/FXO SUPERVISION (OPTION 930A-25)

The user may also purchase Option 930A-25 (FXO/FXS Supervision) to provide the capability to operate on Foreign Exchange circuits in Drop and Insert and THRU modes on PCM trunks. A typical display is shown below:

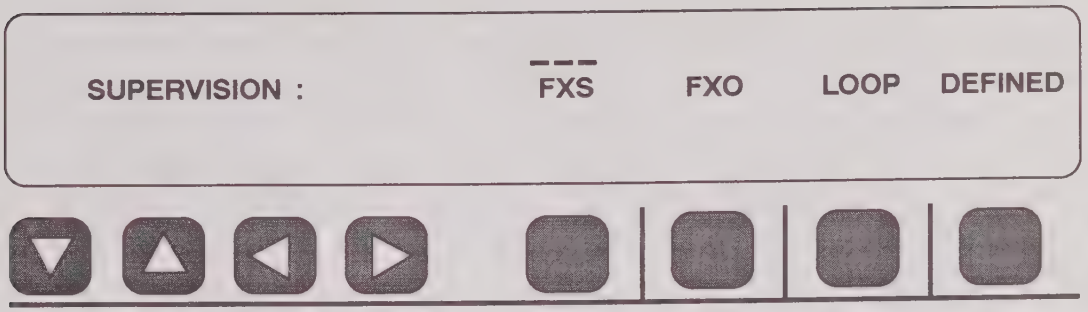


Pressing Softkey 1 in the above display selects Foreign Exchange Station (FXS) supervision (if Option 930A-25 has been installed) which causes the Model 930A to simulate the station end (PBX) of a foreign exchange circuit. The 930A display becomes:

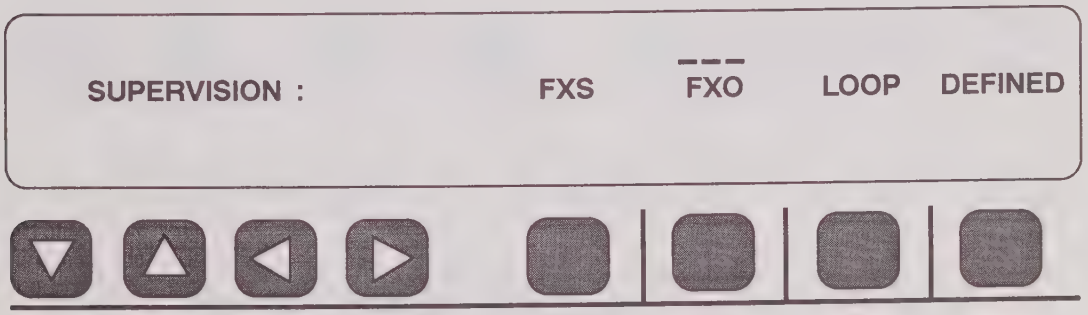


In **FXS** mode, when the 930A is On-Hook, it sends the Loop Idle bit pattern (A=0, B=1). When the 930A is Off-Hook, it sends the Ground on Ring bit pattern (A=0, B=0) until the far end Foreign Exchange Office (FXO) returns Ground on Tip (A=0). The 930A will then send the Loop Closed bit pattern (A=1, B=1). This mode works equally well with Loop Start and Ground Start offices.

The 930A assumes that the far end is sending FXO supervision, and interprets A=0 to mean Tip Ground (Off-Hook) and A=1 to mean No Tip Ground (On-Hook). B=0 is interpreted as Ringing, and B=1 is interpreted as No Ringing.



Pressing Softkey 2 in the above display selects Foreign Exchange Office (FXO) supervision (if Option 930A-25 has been installed) and causes the 930A to simulate the central office (CO) end of a foreign exchange circuit. The Supervision Screen changes to:



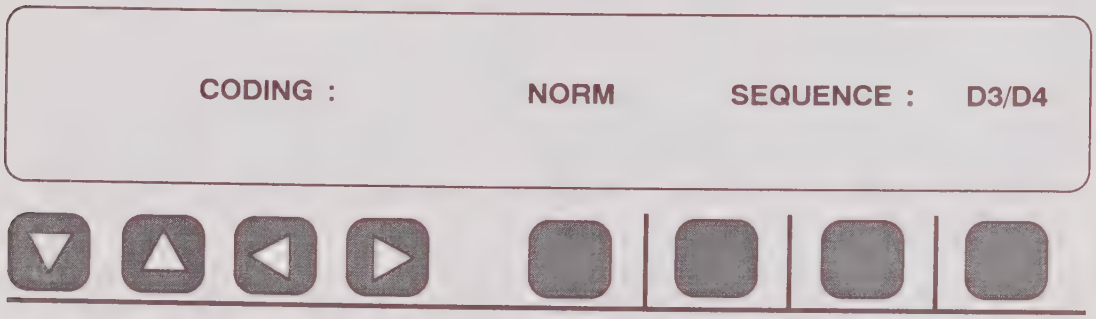
In **FXO** mode, when the 930A is On-Hook, it will send the No Ground on Tip bit pattern (A=1, B=1). When the 930A is Off-Hook, it will send the Ground on Tip bit pattern (A=0, B=1).

The 930A leaves the B bit set (B=1) to indicate No Ringing. The user may send Ringing to the far end by entering Menu Option 21: TOGGLE A\B BITS, and setting the B bit to zero manually. The B bit will revert to a one when the user exits the TOGGLE A\B BITS menu option.

The 930A assumes that the far end is sending FXS supervision and interprets either Ring Ground (A=0, B=0) or Loop Closed (A=1, B=1) as an Off-Hook. This enables the 930A to operate with either Loop Start or Ground Start FXS equipment. The 930A interprets Loop Idle (A=0, B=1) as an On-Hook. The unused bit pattern (A=1, B=0) is also interpreted as an On-Hook.

4-6.2.4 KEY OPERATION IN THE CODING AND SEQUENCE SCREEN

This option screen allows the user to select either Normal (Robbed Bit or 7-5/6 bit signaling) or CCIS (all 8 bits in every frame are used for data and signaling is carried over a separate path out of band) encoding, and to set the proper channel numbering sequence (D1D, D2, or D3/D4). A typical display is shown below:



The functions of the front panel keys within this option screen are as follows:

The Left Arrow key returns to the Supervision screen.

The Right Arrow key advances to the PCM Diagnostics screen.

Softkey 1 selects either Normal or CCIS signaling.

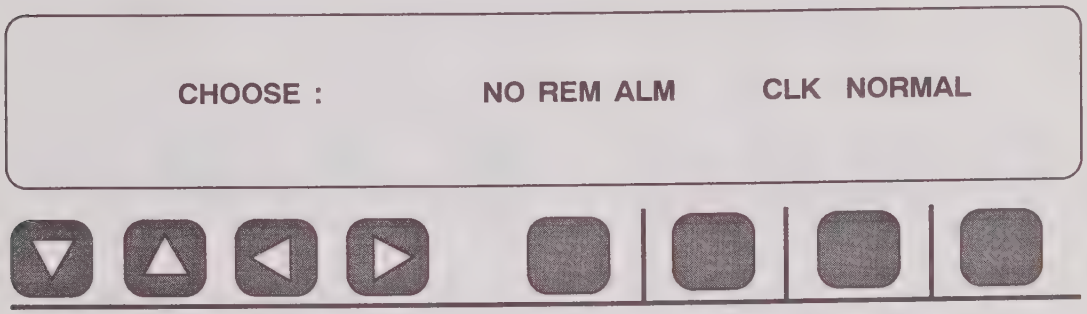
Softkeys 2 and 3 are inactive.

Softkey 4 is a wheel and allows the user to select either D1D, D2, or D3/D4 channel numbering.

Pressing the Right Arrow key will advance to the PCM Diagnostics option screen which is described in the next sub-section.

4-6.2.5 KEY OPERATION IN THE PCM DIAGNOSTICS SCREEN

This option screen allows the user to send Remote Alarm (Yellow Alarm) or to skew the 930A's internal clock by 100 Hz if it is desired to cause Frame Slips. A typical display of this screen is shown below:



The operation of the front panel keys within the PCM Diagnostics option screen are as follows:

The Left Arrow key returns to the Coding and Sequence screen.

The Right Arrow key brings back the Primary Option screen.

Softkey 1 toggles between SEND REMOTE ALARM and NO REMOTE ALARM.

Softkeys 2 and 4 are inactive.

Softkey 3 toggles between normal clock (1.544 MHz) and skewed clock (1.5439 MHz).

If Softkey 1 had been pressed, the 930A would start sending the Remote Alarm and the display would become:

Remote Alarm (Yellow Alarm) is the condition where bit number 2 in all 24 time slots is forced to zero (low) in every frame. At the far end this alarm condition causes the channel bank to go OFF HOOK and essentially busy itself out to prevent usage of that trunk group. The Model 930A can send Remote Alarm only in the TX/RX mode when it originates all 24 channels.

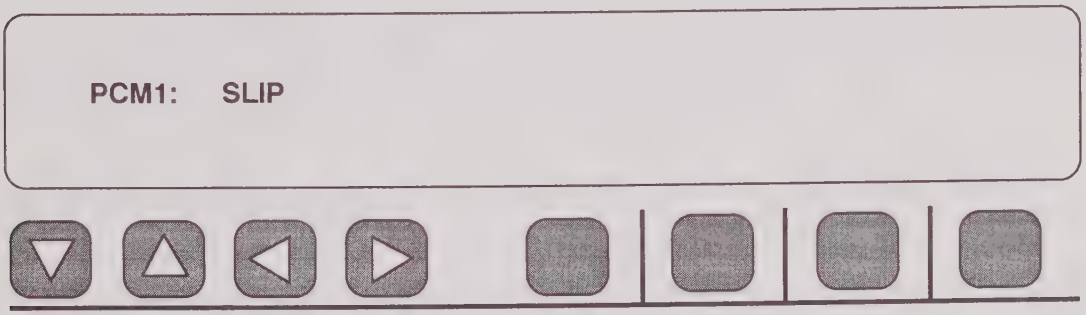
If the operator suspects that the equipment at the distant end of a T-1 span is not loop-timed as it should be and is causing frame slips, a means of determining this is to offset the clock in the 930A. Pressing Softkey 3 will cause the 930A display to become:

Slips are said to occur when the transmit and receive PCM bit streams in a given span are not synchronous with each other. In a synchronous system such as T-1, this condition may arise from the situation where both ends of the circuit are attempting to provide clock. In a synchronous system there can only be one master clock and all other equipment in the system derive their timing from the master clock source. In some instances, notably during maintenance, a channel bank or multiplexer may be switched to its own internal clock and taken out of the loop timed (derived clock) mode.

At the end of the maintenance, if the channel bank is not returned to loop timing, then the two opposing clocks fight each other and slips occur. This often takes a while to show up, since the clocks are usually close in frequency and relatively stable, so slips are rare.

Skewing, or off-setting, the clock at one end of the circuit will quickly show this condition by causing frequent slips. If the circuit is correctly set up with only one end supplying clock, then the frequency offset will have no effect and no slips will be produced.

If slips are detected, the Model 930A will momentarily interrupt whatever it is doing and flash the following display:



NOTE:

Since divestiture of the Bell System and the emergence of competing long distance carriers (MCI, US Sprint, and others) there now exists a Pleisiosynchronous digital network. That is, each carrier has its own master clock. While these clocks are each very precise, they are not the same clock and so they are not phase locked to each other. This means that slips are likely to occur when these carriers interface to the AT&T network. This is due to the fact that there is no single master clock in the circuit. The number of slips should be within the established specifications over a 24 hour period because the clocks are each derived from atomic standards but there are likely to be more slips than there were previously.

4-6.2.6 PCM ERROR MESSAGES

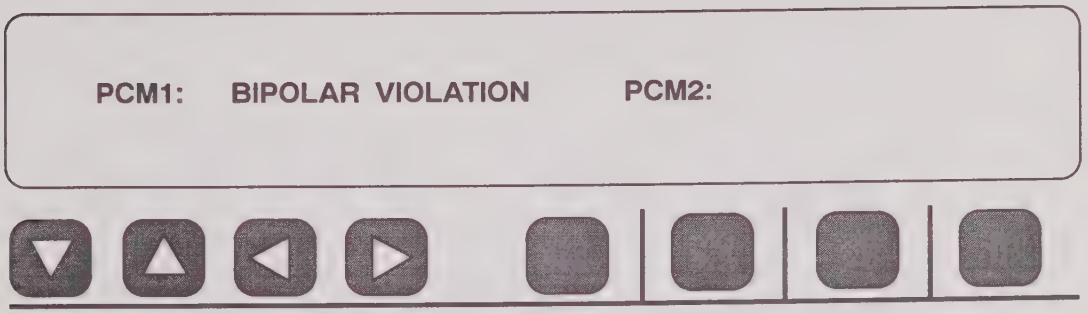
If an error or abnormal condition on the PCM span is detected, the 930A will produce an audible beep, clear the screen, and briefly display the error message. The errors are displayed in a hierarchical manner. That is, if NO PCM is detected, the 930A will report it, but not a FRAME LOSS. Similarly, FRAME LOSS takes precedence over a FRAME ERROR or BIPOLAR VIOLATION. The 930A DS-1 PCM Error Messages, in hierarchical order, are:

1) NO PCM! --No incoming PCM bit stream has been detected.
2) FRAME LOSS -- Frame synchronization cannot be acquired or has been lost (RED ALARM).
3) FRAME ERR -- An error has been detected in a Frame bit.
4) SLIP -- The incoming and outgoing bit streams have lost clock synch.
5) BIPOLAR VIO -- Two consecutive pulses of the same polarity appear on the span line which is a violation of the Alternate Mark Inversion (AMI) line code format.
6) REMOTE ALARM -- YELLOW ALARM is being received indicating the far end of the circuit is in an alarm condition.

NOTE: A "Red Alarm" is generally signaled if either a "NO PCM !" or a continuous "FRAME LOSS" error message occurs. A "Yellow Alarm" corresponds to the REMOTE ALARM condition. For a precise description of "Red Alarm", refer to AT&T Publication 43801.

If two or more errors are detected on the same PCM bit stream, only the highest priority error will be displayed. The Model 930A, however, has the capability to look at two PCM bit streams simultaneously if Option 930A-09 has been installed. In this case errors which occur are labeled according to the PCM board which detects them (With Option 930A-09 there are two PCM boards-one for each direction).

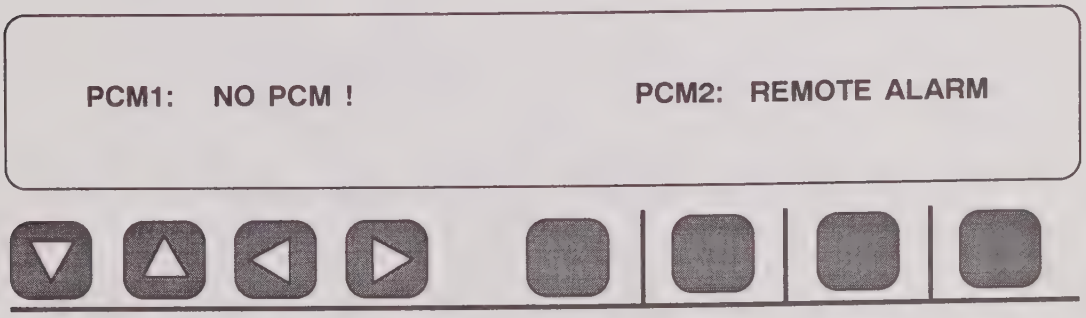
An example of an error message (with Option 930A-09 installed) under these conditions is shown below:



This indicates that a Bipolar Violation was detected on board 1 but no errors were detected on board 2. Note that, in the case of Option 930A-08, there is no board 2 and so PCM errors are only detected in one direction at a time.

Another example of an error message with the dual direction option 930A-09 installed follows:

With the 930A in the THRU mode, if the output of the originating end is disconnected, the terminating end receives no PCM and sends back the Remote Alarm. The error message, with the 930A in SEND-1, appears as:



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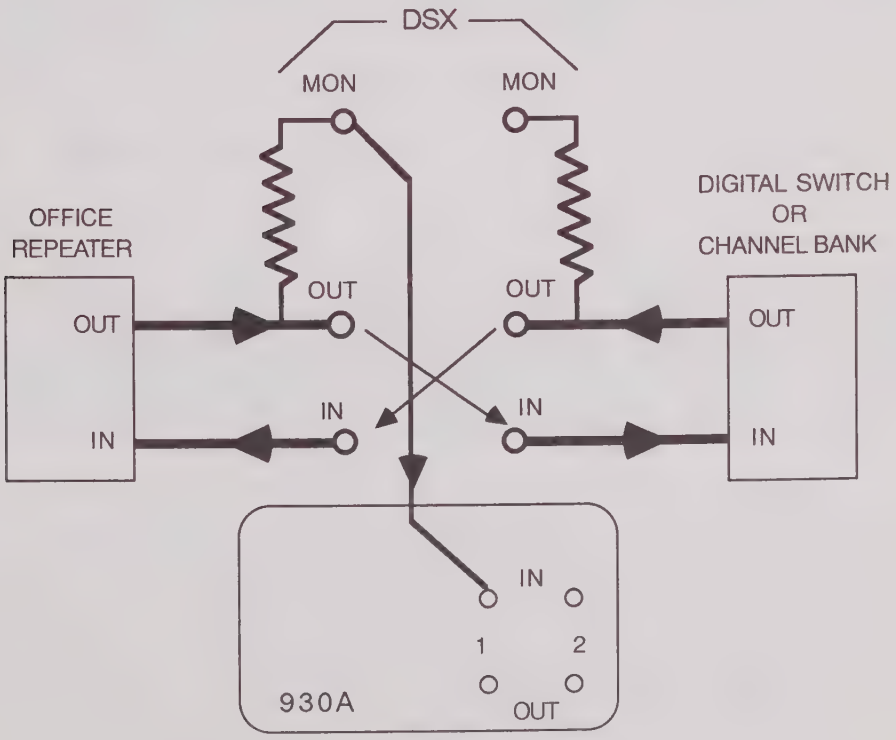
4-6.3 PCM TRUNK TESTING USING THE 930A

In most cases the 930A will be connected to the PCM span lines at what is referred to as the DSX. The Digital Signal Cross-Connect (DSX) is merely a large jackfield which consists of either the older Western Electric Type 310 jacks or the newer tiny telephone or bantam jacks. In the telephone central office environment, all DS-1 digital equipments interface with each other at the DSX. There are no direct connections between equipment. The DSX provides test access and is a demarcation point for record keeping. The following paragraphs and figures describe some of the ways in which a 930A may be connected to the DSX for testing. The 930A display screens will vary depending upon what tests are being performed. Refer to these figures to decide the correct mode of operation for the testing desired.

4-6.3.1 MONITORING A T-1 LINE

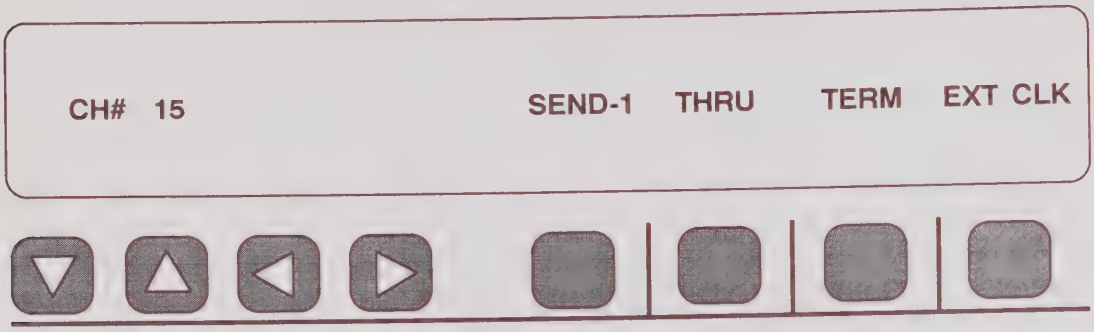
The most basic test mode is Monitor Only, as shown in Figure 4-7 below:



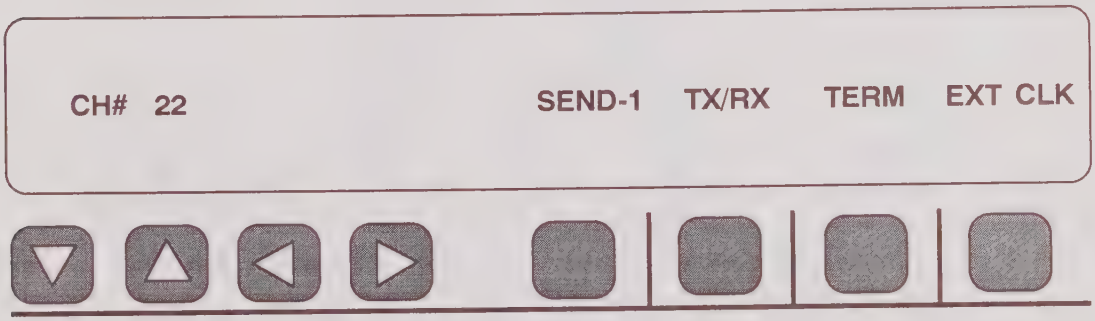
PCM MODE: TX/RX

MONITORING A PCM SPAN LINE
FIGURE 4-7

All PCM testing with the 930A is initiated from the Primary PCM Option Menu. An example of this menu is shown below:



When connected to a single Monitor jack of a DSX, the 930A should be set to TX/RX mode by pressing Softkey 2. The 930A must also be placed in the TERM mode by pressing Softkey 3 and should be deriving clock from the line being monitored. Press Softkey 4 to select External (EXT) clock if EXT is not already displayed. The correct 930A display will look somewhat like:



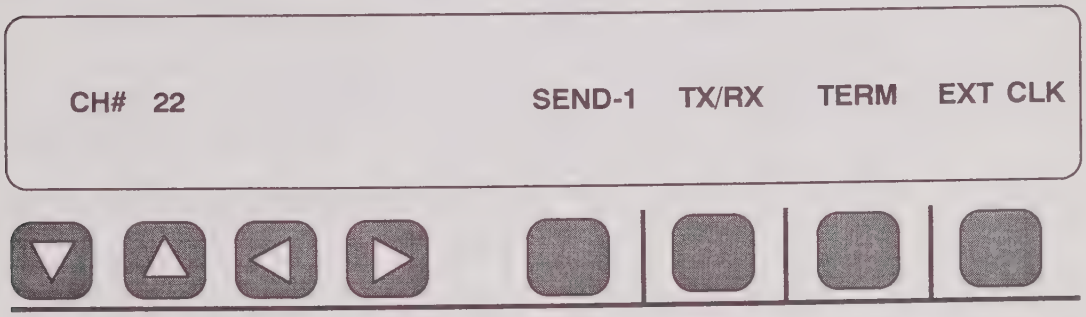
The display over Softkey 1 is automatically set to SEND-1 in the TX/RX mode.

Connecting the 930A as shown in Figure 4-7 above enables the user to monitor any of the 24 trunks on a PCM span line. In this example, the test set is connected to only one direction of transmission and can only receive VF signals and supervision from that direction. Once the desired timeslot has been selected with the 930A, any of the receive functions may be used.

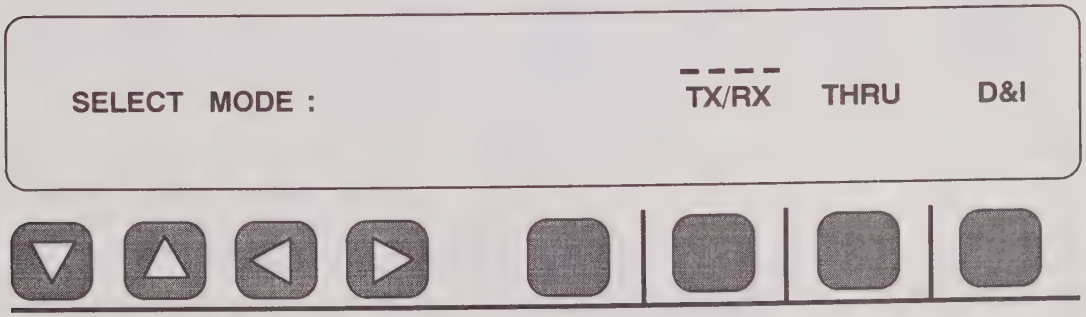
The Monitor mode of operation is very useful for testing in-service trunks because it does not disturb the traffic or cause hits on the span line. To look at the transmission from the other direction it would be necessary to plug the test set into the Monitor jack coming from that direction.

This is the so-called "Half-Channel" measurement technique which earlier PCM Access test sets employed because they had only one receiver and one transmitter. The 930A equipped with Option 930A-08 would be used in this manner.

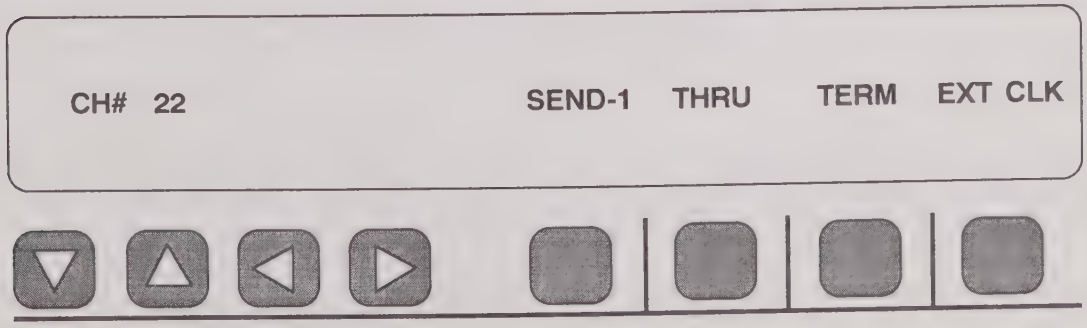
When equipped with Option 930A-09 the 930A enables the user to Monitor both directions of transmission. Such a connection is shown in Figure 4-8. Set-up is similar to that previously described for single direction monitoring except that THRU mode must be selected using Softkey 2 instead of the TX/RX mode. Using the display from the previous page:

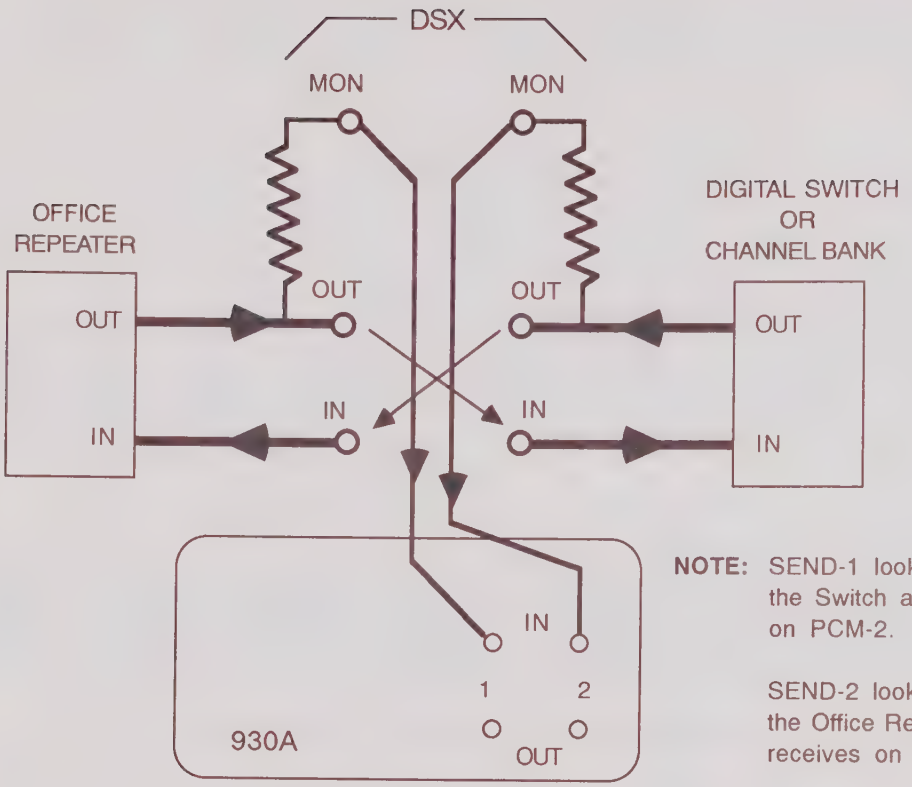


Pressing Softkey 2 will bring up the SELECT MODE display as shown below:



The highlight shows that TX/RX is the current mode and pressing Softkey 3 selects the THRU mode. The 930A display should then look somewhat like:





DUAL DIRECTION PCM MONITORING
FIGURE 4-8

In the dual direction monitoring mode, the 930A displays trunk supervision for both directions of transmission. VF information on a selected channel is decoded for one transmission direction at a time.

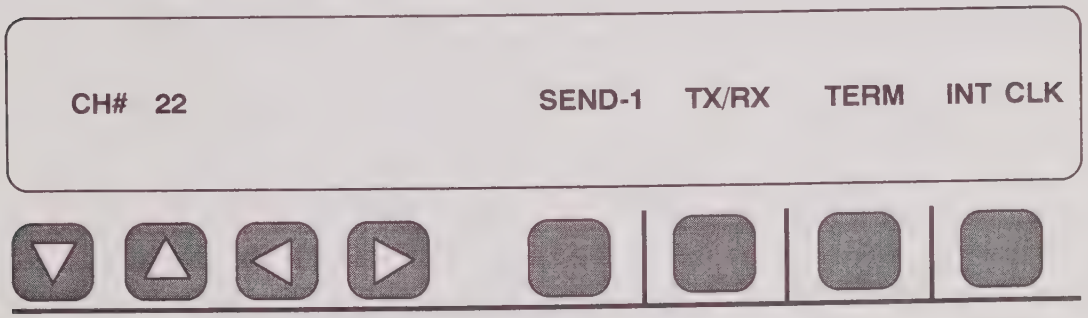
In the THRU mode, unlike TX/RX, SEND-1 enables the user to monitor channels coming in on the PCM IN 2 jack and SEND-2 monitors channels on the PCM IN1 jack. Selection between SEND-1 and SEND-2 is made by means of Softkey 1 and the user does not have to switch test cords around to look in either direction.

Supervision sense (Originate vs. Terminate) is dependent upon the direction selected. Refer back to Section 4-6.2.2 for details.

4-6.3.2 SINGLE DIRECTION TESTING ON T-1 LINES

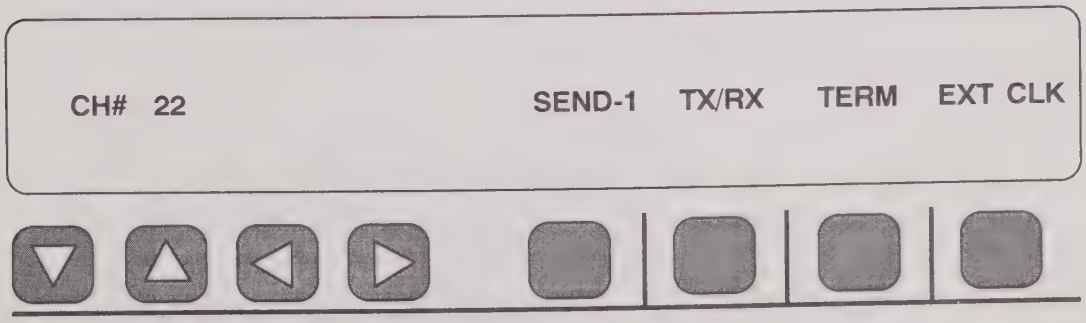
For testing trunks on out-of-service span lines (pre-cutover or turned down for maintenance), the 930A can generate, as well as receive, a DS-1 signal. In this type of application, the 930A would be connected as shown in Figure 4-9.

The Model 930A (with PCM Trunk Type selected) would then be placed in the TX/RX mode by pressing Softkey 2. The user would set the clock source to either internal (INT) or external (EXT) as appropriate by pressing Softkey 4 as needed. If the 930A is being used to simulate the Telephone Central Office end of a circuit or in any application where it is simulating equipment that is supplying the timing, then the 930A should be set to INT. The 930A PCM display would look somewhat like:



This enables the equipment to which the 930A is connected to operate in the "Loop Timed" mode.

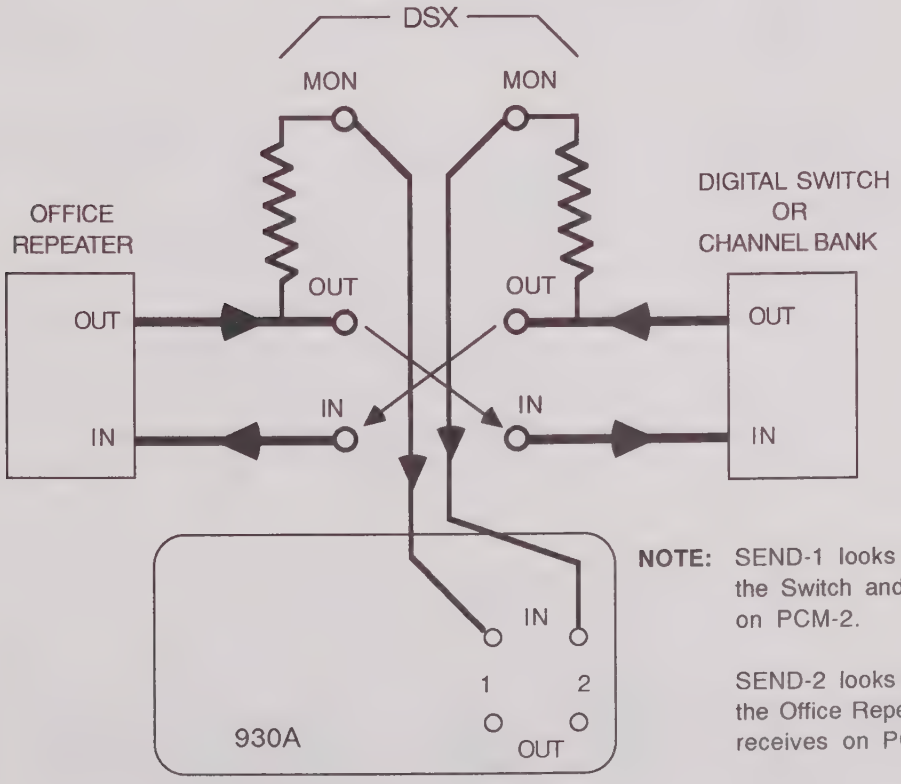
If the 930A is being used to simulate the channel bank or customer premises end of a circuit, then it will usually be set in the EXT timing mode since the equipment under test will normally be supplying the clock. The display in that case will appear somewhat like:



Trunk transmission and signaling can be tested automatically using the 1/2/3 circuit as placed in service joining the 1/2/3 trunks by simulating either end of a circuit. In the above example the trunk was placed in 1/2 circuit mode to simulate the odd side of the circuit. By test knowing the keys (simulate the Switch) simply set the trunk to NIL circuit mode and monitor the test cords to the DSX being known that knowing the system diagnostics

4-6.3.3 DROP AND INSERT TESTING ON A T-1 LINE

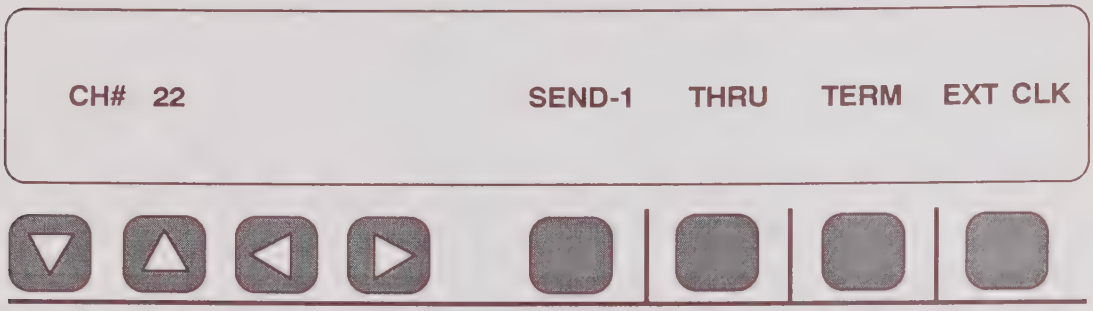
If it is necessary to send a signal over one of the 24 channels (trunks) on a span line when the trunks are in-service, the 930A should be used in the Drop and Insert mode (Requires Option 930A-09 Dual Direction Drop and Insert). In this mode of operation, the DS-1 span line signal is fed through the test set which is, in effect, in series in the line. When the 930A is placed in the Drop and Insert mode, the VF signals and supervision coming in on the selected channel are "Dropped" by the set and in their place the 930A "Inserts" its own VF signal and supervision information. The other 23 channels pass through the test set unaffected. The question is, "How do we place the test set in series with the line without dropping the entire system"? The answer is that the 930A should first be set to the THRU mode by pressing Softkey 2 in the same manner previously described. Next, the 930A should be connected to the DSX as shown in Figure 4-10.



PCM MODE: THRU

PREPARATION FOR DUAL DIRECTION DROP AND INSERT
FIGURE 4-10

Note that Figure 4-10 shows the same connection as previously employed for dual direction monitoring and the 930A display is somewhat like:



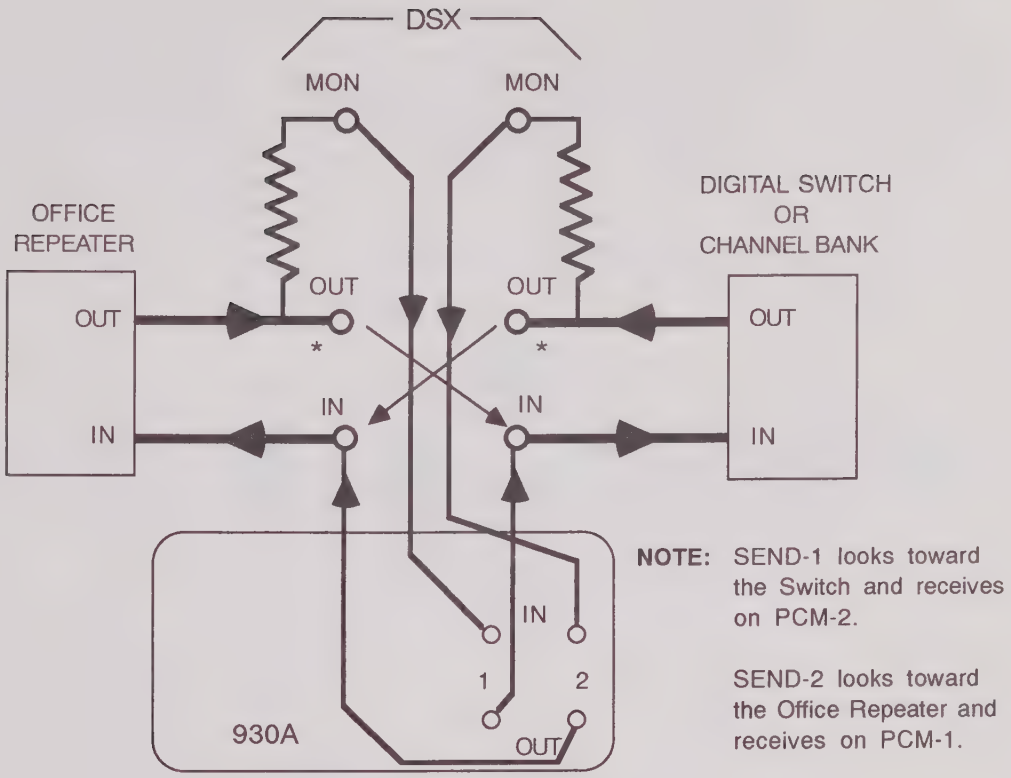
This is the first step in what is actually a two stage procedure. Once the set has been connected in this manner and is satisfactorily receiving PCM from both directions, the user may proceed to the second step.

The user should first plug test cords into the two PCM OUT jacks on the 930A before going on.

The second step consists of plugging the two OUTPUT test cords from the 930A into the appropriate DSX "IN" jacks as shown in Figure 4-11. To avoid unterminating the span line it is good practice to insert 100 ohm terminating plugs in the DSX "OUT" jacks of the system under test.

NOTE: It is likely that plugging into the DSX IN jacks may cause a momentary "Hit" on the line and can cause the equipment on either end to try to reframe. If the user inserts the test cords quickly there is less chance of an outage but the possibility exists that initial connection of the test cords for Drop and Insert may cause a loss of service while the equipment is reframing.

Once in the Drop and Insert mode, the Model 930A purposely does not allow the operator to scroll through the PCM channels in a terminated mode. The Model 930A instantaneously switches itself to the "THRU" mode as the operator starts to change channels. The operator may then go to the desired channel and monitor it without disturbing the system. If it is desired to actually test the new channel in the Drop and Insert mode, the operator must then select the D&I mode by pressing Softkey 2 and then choosing D&I from the resulting menu. This prevents the operator causing hits on any of the other PCM channels not under test. As an added indication, the 930A will "Beep" to alert the user to the change in mode from D&I to THRU if Menu Option 15: BEEP ON ERROR has been set to YES (Refer to Section 3-12.6).

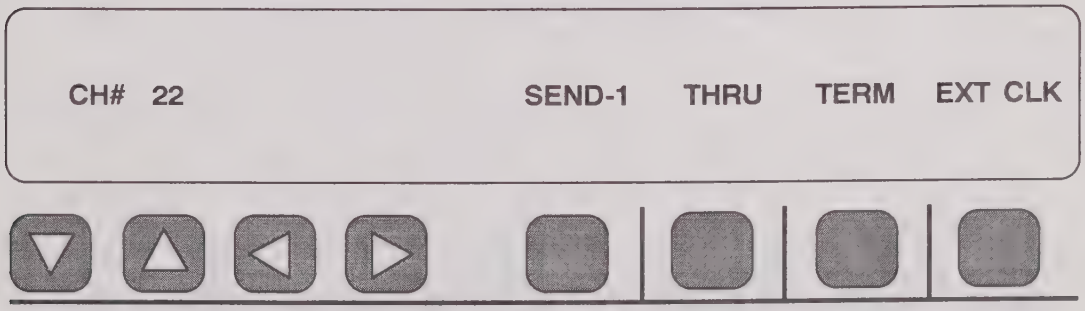


PCM MODE: THRU OR D&I

(* 100 ohm Termination Plug may be required)

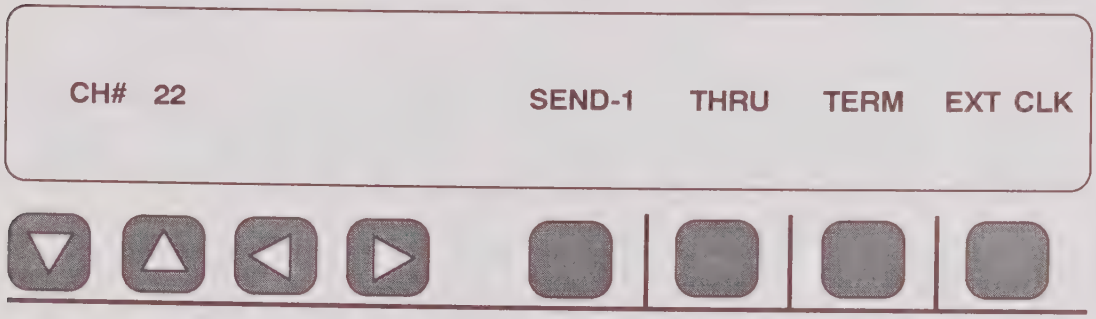
DUAL DROP AND INSERT
FIGURE 4-11

The previous 930A display is repeated below:

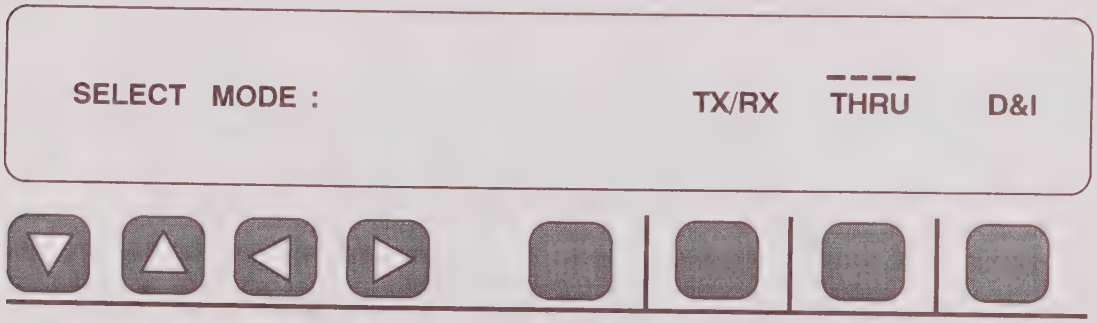


Pressing Softkey 1 on the 930A allows the user to test either toward the Office Repeater or toward the Digital Switch by selecting SEND-1 or SEND-2. The user may switch direction at will by pressing Softkey 1.

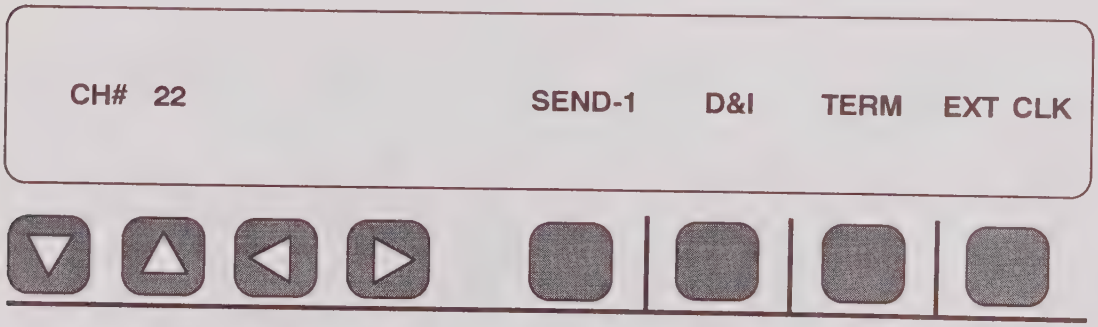
To avoid interfering with operating trunks on the span line it is good practice to Monitor the channels in the THRU mode before switching to the Drop and Insert mode. This can be accomplished easily by pressing Softkey 2 and switching between THRU and D&I modes. The 930A displays under these conditions appear as follows:



Pressing Softkey 2 would bring up the following display:



The highlight over THRU indicates that it is the currently selected mode. To select Drop and Insert, simply press Softkey 4 and the 930A will enter the D&I mode and the display will change to:



To change back to the THRU mode simply press Softkey 2 again and select THRU mode by pressing Softkey 3 in the SELECT MODE menu. In the THRU mode, all 24 channels are undisturbed by the test set which monitors only.

4-6.4 MENU OPTION NUMBER: 20 24 BIT DISPLAY

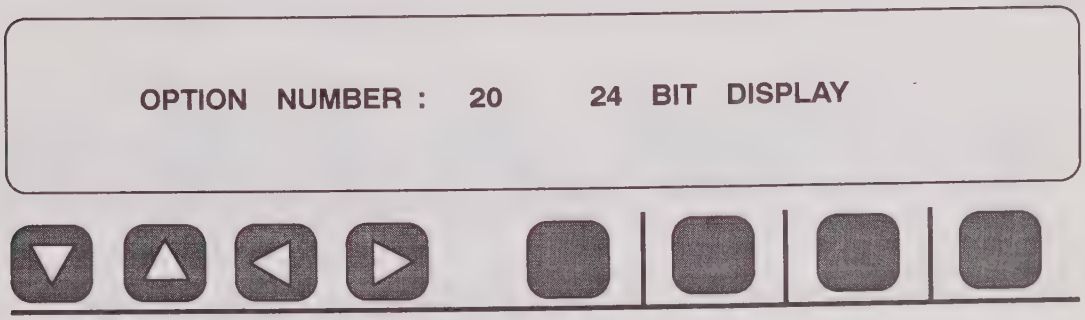
When either PCM option has been installed in the 930A, additional menu options become available under the OPTION MENU Function key. Menu Option number 20 enables the user to look at the supervision bits on all 24 channels simultaneously.

To use the 24 bit Display function, once the PCM trunk type has been selected, perform the following steps:

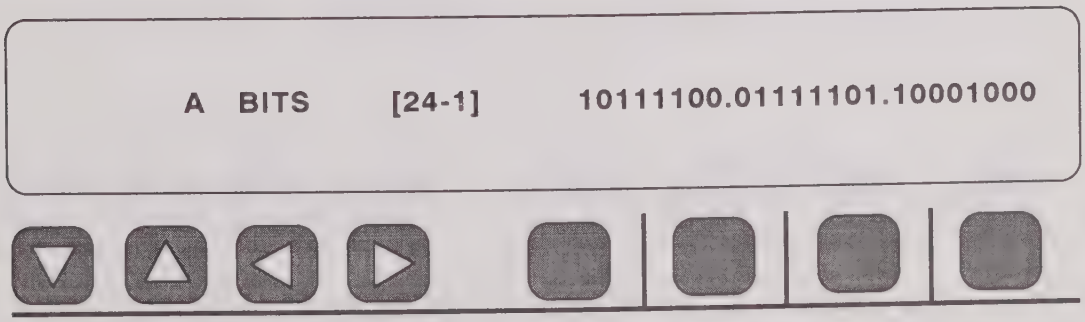
Press the OPTION MENU function key.

Use the UP/DOWN arrow keys to select Menu Option 20: 24 BIT DISPLAY.

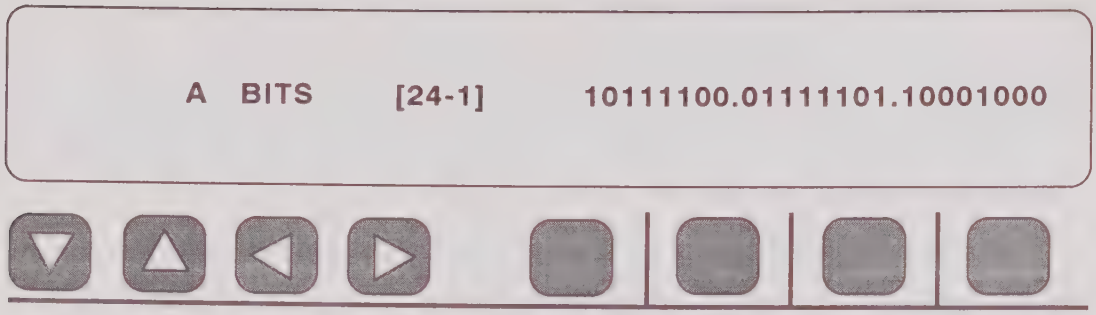
The 930A display will appear as:



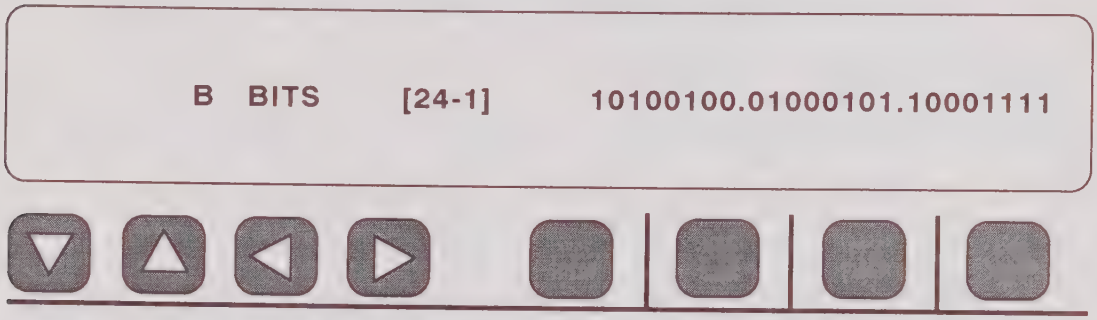
Pressing any Softkey will enter the menu option and the 930A display will assume an appearance similar to the following example.



where "10111100.01111101.10001000" represents a typical 24 bit display of ones and zeroes, showing the supervision on all 24 channels.



The displayed digits are broken up into three groups of eight for easier reading. The channels are displayed in descending order, left to right, from channel 24 to channel 1. Softkey 1 allows the user to toggle between the A and B bit displays. The UP/DOWN arrow keys perform the same function. An example of the B bit display follows:



This display is active whenever the 930A is receiving a PCM bit stream. In a Monitor mode this display makes an ideal activity monitor. With option 930A-09 installed, the operator may use this menu option in the THRU and D&I modes also.

In the THRU and D&I modes, switching from SEND-1 to SEND-2 in the main PCM display will enable the user to look at the A and B bits in both directions of transmission.

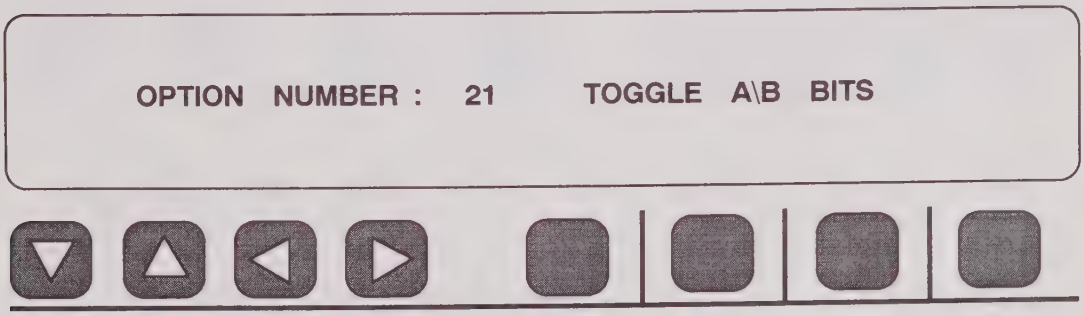
4-6.5 MENU OPTION NUMBER: 21 TOGGLE A/B BITS

Another menu option available when either PCM option has been installed is Menu Option 21: TOGGLE A/B BITS. This menu option enables the user to change the state of the transmitted supervision bits from one to zero or vice versa. To use this menu option, first perform the following steps:

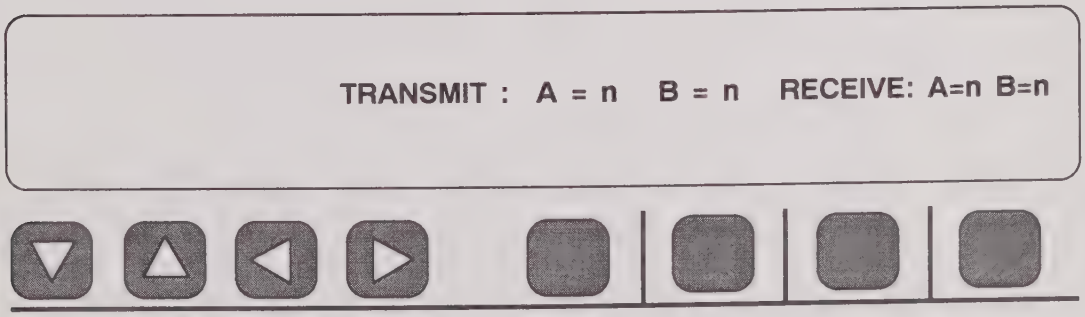
Press the OPTION MENU Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 21: TOGGLE A/B BITS.

The 930A display will be as shown below:



Once at option number 21, press any Softkey to enter, and the 930A display will appear as:

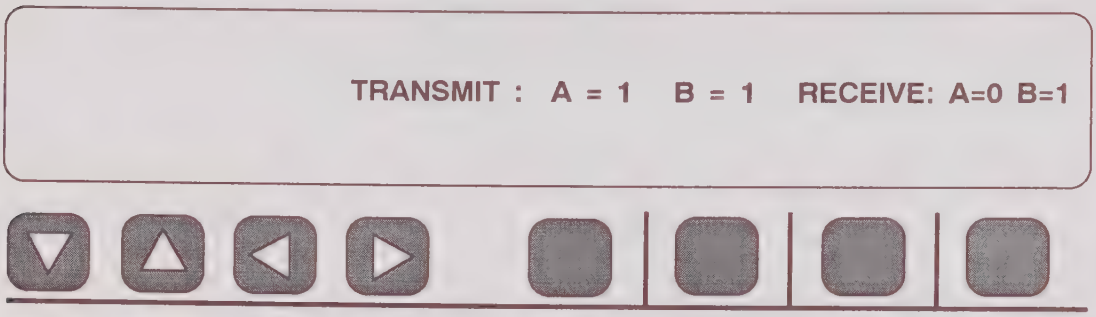


showing the Transmit and Receive supervision bits for the currently selected PCM channel. Each "n" will be equal to a zero or a one. Softkey 1 toggles the transmitted A bit between 0 and 1, and Softkey 2 toggles the

transmitted B bit between 0 and 1. The Hook Switch is inactive and supervision is entirely under control of the Softkeys.

In the THRU mode, the Transmit and Receive supervision bit displays monitor the states of the A and B bits in the selected channel in both directions. Since the THRU mode is a monitor mode, the state of the A and B bits cannot be changed (Softkeys 1 and 2 are inactive).

A typical display follows:



Pressing any Function key will exit the option.

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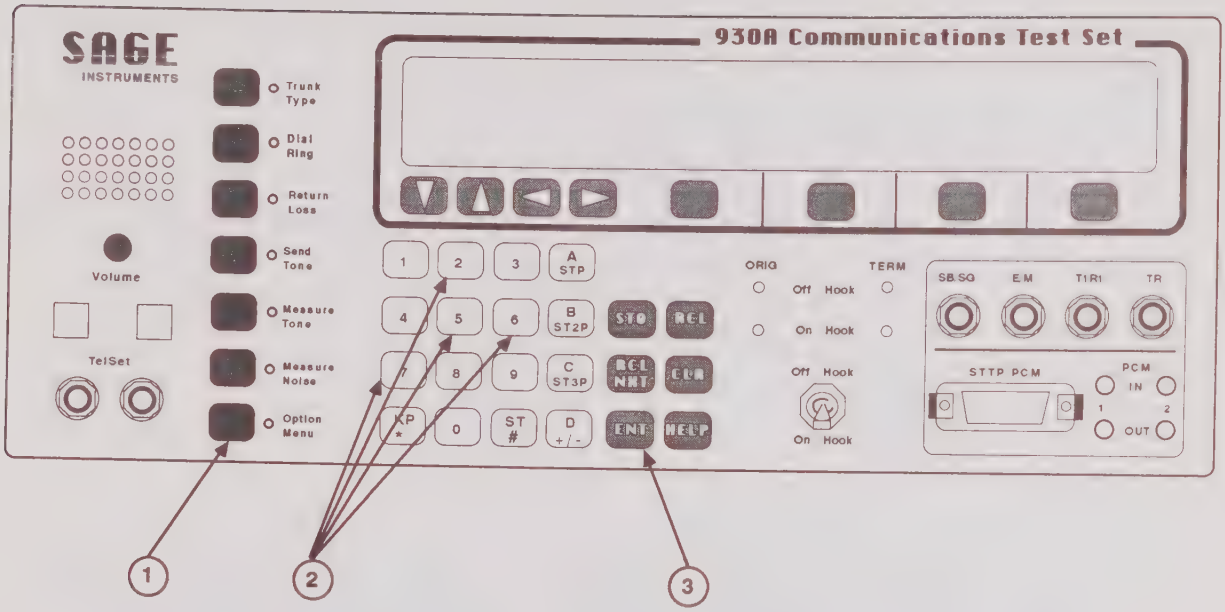


To select the ROTL/RESPONDER/INTERROGATOR Menu Options:

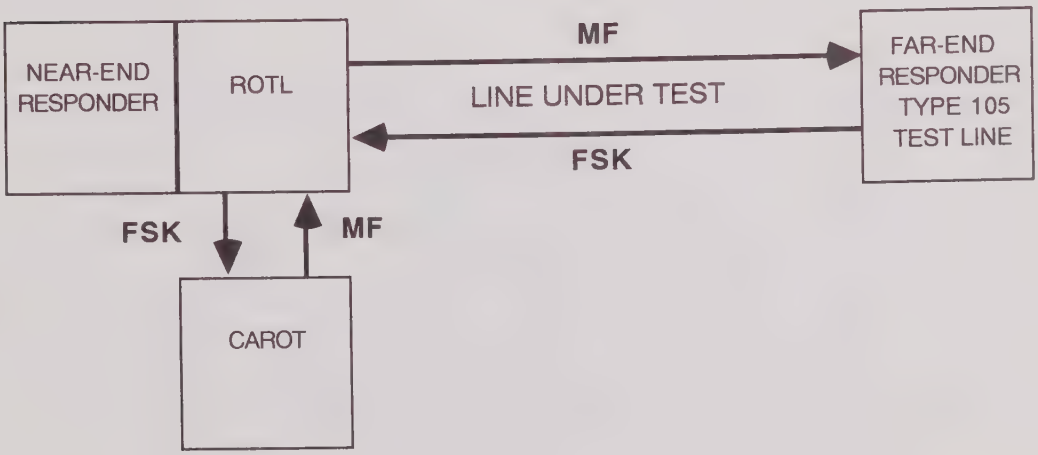
1. Press the OPTION MENU function key.
2. Use the numeric keypad to enter:
   - 25 for the 105 FAR END RESPONDER
   - 26 for the ROTL/NEAR END RESPONDER
   - 27 for the ROTL INTERROGATOR
3. Press the ENT(Enter) key to complete the numeric entry and selection.
4. Refer to Section 4-7 for further information.

ROTL/RESPONDER/INTERROGATOR
FIGURE 4-12

4-7 ROTL/RESPONDER/INTERROGATOR (OPTION 930A-12)

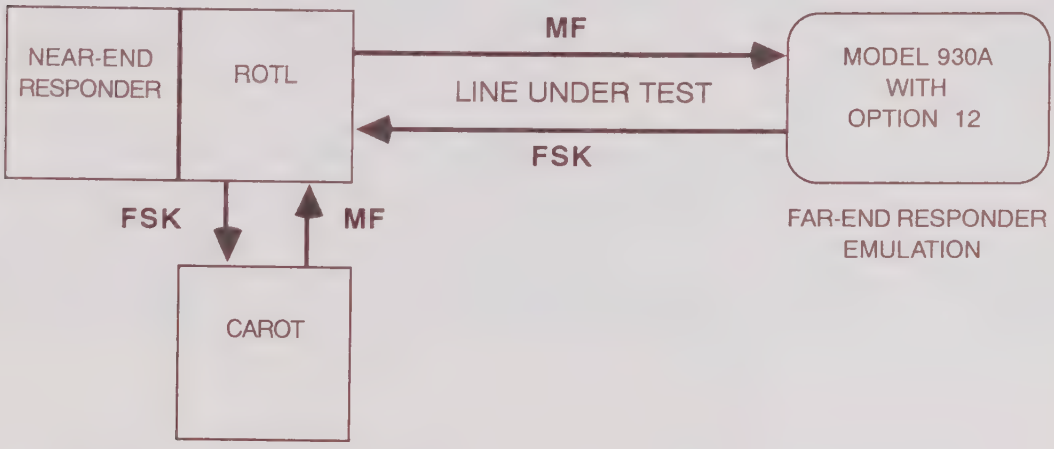
The Model 930A, when equipped with Option 930A-12, provides a test capability similar to the Centralized Automated Routining Of Trunks (CAROT or 52A system) in manual or remote control applications. The functions of a Remote Office Test Line (ROTL), Near End Responder, Far End Responder and Interrogator are contained under Menu Options 25, 26 and 27. The Responder portions are compatible with WECo Type 105 test lines and enable the user to measure 1004 Hz loss, noise, noise with tone, gain/slope, ERL, SRL-LO, and SRL-HI. If Option 930A-10 or -11 has been installed, the user can connect a printer to the 930A to obtain a hard copy of the test results.

In a typical 52A system, CAROT commands a ROTL, via MF tones, to dial up and command a far-end responder. Tests are performed and data is returned to the ROTL by FSK tones. All two-way tests require the ROTL to have a near-end responder as well. All data is relayed back to the 52A test position via FSK encoding. The diagram below shows a typical connection.



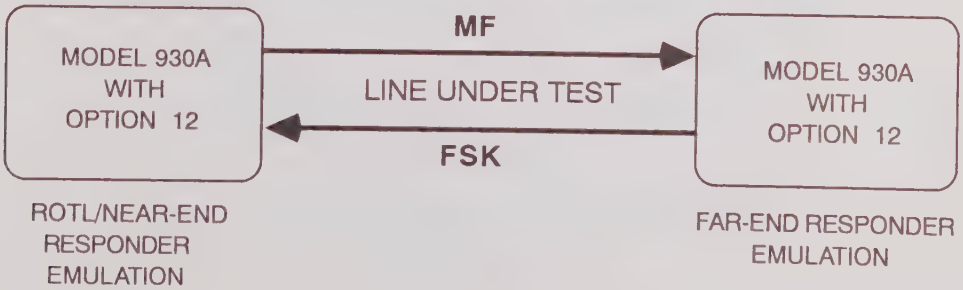
TYPICAL 52A (CAROT) SYSTEM
FIGURE 4-13

If the Model 930A is being used as a portable test set at a location where there is no dial up responder, it can be attached to the line and used as a type 105 far-end responder. It may also be convenient to use this capability when the Model 930A is installed as permanent test equipment in a switch or PBX. When configured as a far-end responder, the Model 930A can be accessed by the CAROT system. Type 105 testing can be originated at the operating telephone company and terminated at the Model 930A. Figure 4-14 shows a typical connection.



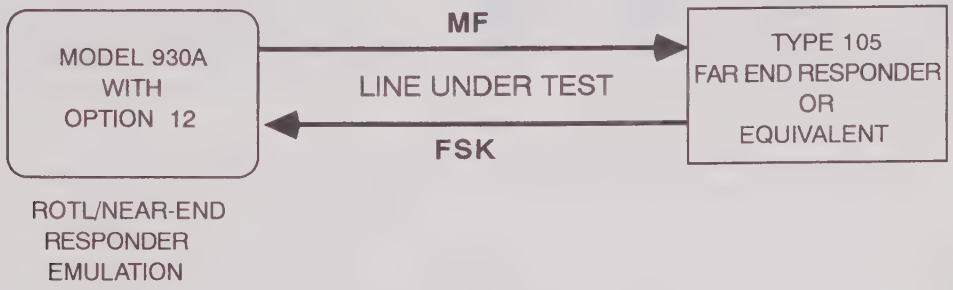
MODEL 930A EMULATING A TYPE 105 FAR-END RESPONDER
FIGURE 4-14

The Model 930A can also function as a manual ROTL under local operation or via the RS-232C interface (Option 930A-10 or -11). In this case, the Model 930A is used to command the far-end responder (another 930A with Option 930A-12, a Type 105 responder, or equivalent) and run tests. The 930A with Option 930A-12 includes a near end responder for two way testing. A typical connection between two Model 930As is shown below.

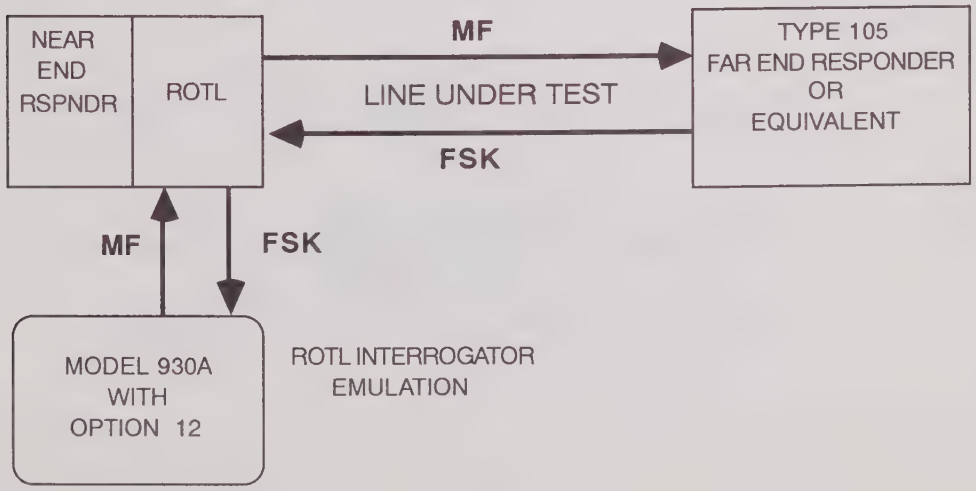


A switch equipped with the 930A in the above configuration could originate type 105 testing of circuits which terminate at any location where a type 105 test line or equivalent exists. Another 930A could be located at the far end and could terminate the tests when configured as a far end responder.

The Model 930A can perform the manual ROTL function with any 52A format far end responder/105 test line as shown below.



The Model 930A can also function as a ROTL Interrogator. This function is useful when a ROTL is already installed at the user's location, but the user does not have access to the CAROT controller. A typical connection is shown below.



MODEL 930A ACTING AS A ROTL INTERROGATOR
FIGURE 4-15

The Model 930A thereby enables the user to initiate ROTL testing manually (without going through the CAROT controller). This makes the testing capabilities of an installed ROTL more accessible to local technicians.

The 930A currently cannot operate as an originating ROTL under direct control of the CAROT system and so this is a manual function for the time being.

The set-up and operation of the Model 930A equipped with Option 930A-12 for each of the preceding situations is described in the following sub-sections.

4-7.1 MENU OPTION NUMBER: 25 FAR END RESPONDER

When Option 930A-12 has been installed in the 930A the user can configure the test set as a Type 105 compatible Far End Responder. The 930A can then be controlled by any 52A format compatible ROTL and enables the user to measure Loss, Noise, Noise with Tone, Gain/Slope, and Return Loss.

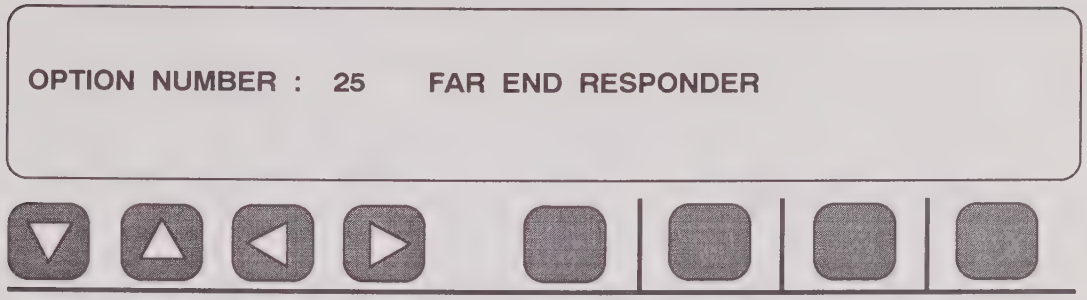
Before testing, the user must select the appropriate Trunk Type (Refer to Section 3-6) and connect the 930A to the circuit. Once this has been accomplished, perform the following steps to place the 930A in Far End Responder mode:

Press the Option Menu **Option Menu** key.

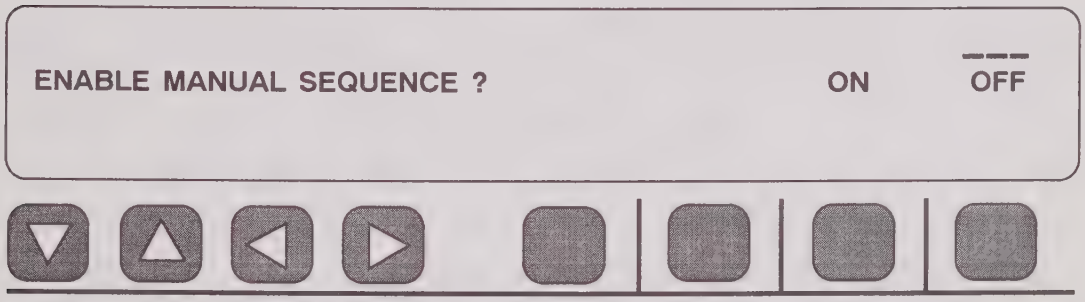
Use the UP/DOWN arrow keys

to select Menu Option 25: FAR END RESPONDER.

The Model 930A display will appear as follows:

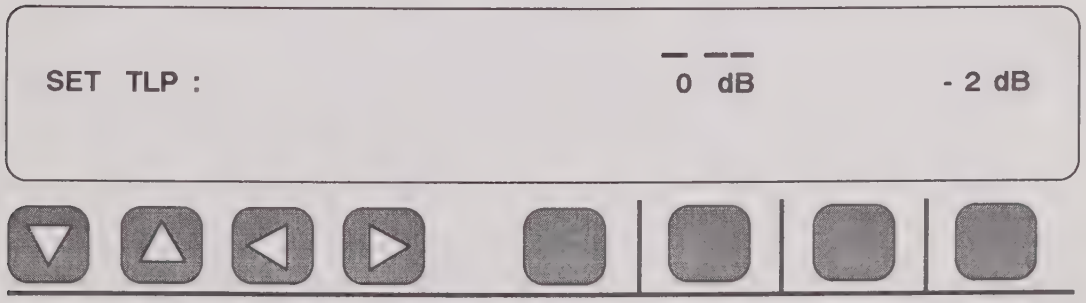


Press any Softkey to enter the option and the 930A display prompts the user through the set-up procedure. The 930A display will first ask:



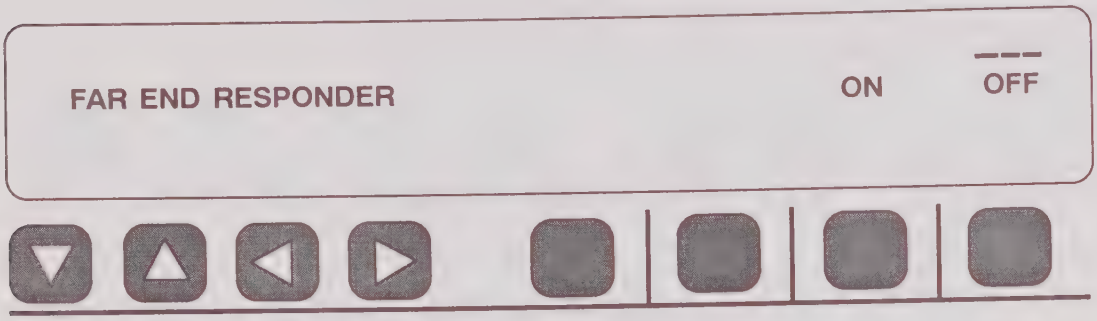
The flashing cursor may appear over either the ON or OFF choice depending upon which was previously selected. The Model 930A always functions in the automatic sequence mode. The manual mode provides a means for performing single direction tests and is most useful for PBX testing.

To enable the manual sequence, press Softkey 3 (labeled ON in the above display) and the 930A will then prompt the operator to set the TLP as shown below:



Press Softkey 2 to select 0 dB or Softkey 4 to select -2 dB TLP. If -2 dB is selected, the 930A inserts a 2 dB pad into its input and output paths.

The user then turns on the far end responder as follows:



Press Softkey 3 and the flashing cursor will appear over the "ON" indication signifying that the 930A is now waiting to be accessed. The above display appears regardless of whether or not the operator chooses the manual sequence and in either case pressing Softkey 3 is necessary to enable the responder function.

When accessed by ringing or far end seizure, the 930A goes off-hook and responds with a 2225 Hz test progress tone (TPT). The 930A then waits for MF commands and performs the corresponding type 105 tests. The 930A will continue in this mode until:

a. It is released by the calling party via an MF "release" command.
b. The calling party goes "On-Hook" (See Note).
c. No MF command is received for 20 seconds (930A defaults to Manual mode if selected).
d. The operator presses the "OFF" Softkey or any Function key on the 930A front panel.

When the 930A is released, or the calling party goes On-Hook, the 930A goes On-Hook for 1 second and then awaits seizure or ringing. If the 930A is allowed to time out (20 seconds without an MF command), it will either go On-Hook or initiate the manual test sequence if it has been selected by the operator.

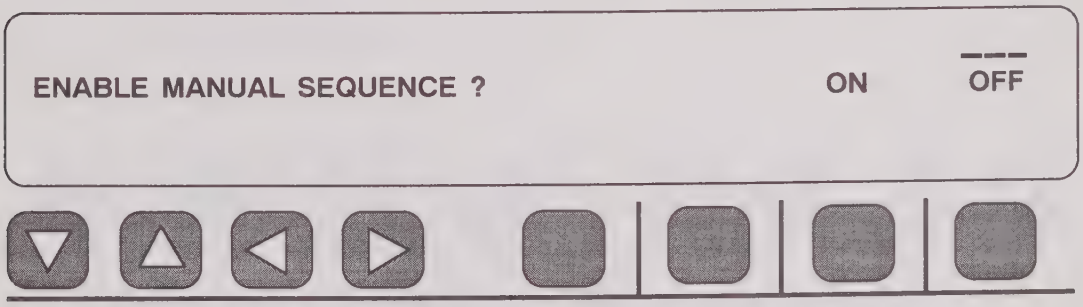
NOTE: If the 930A is on a LOOP trunk and simulating the subscriber (providing CONTACT rather than BATTERY), it will expect the far end to remain On-Hook, and will not treat this as a release condition.

For PBX testing, the manual mode sequence is most useful. If the Manual mode has been selected, the responder is allowed to time out (no MF command is sent) for 20 seconds or more. The Model 930A then provides the manual trunk test tone sequence shown below:

1. 9 seconds of 1004 Hz tone at -16 dBm0
2. 1 second of quiet termination
3. 9 seconds of 404 Hz tone at -16 dBm0
4. 1 second of quiet termination
5. 9 seconds of 2804 Hz tone at -16 dBm0
6. 30 seconds of quiet termination
7. Short burst of TPT (2225 Hz) signaling end of sequence
8. On-hook

If the manual test sequence is not enabled, the 930A will return to the On-Hook state after a 20 second time out.

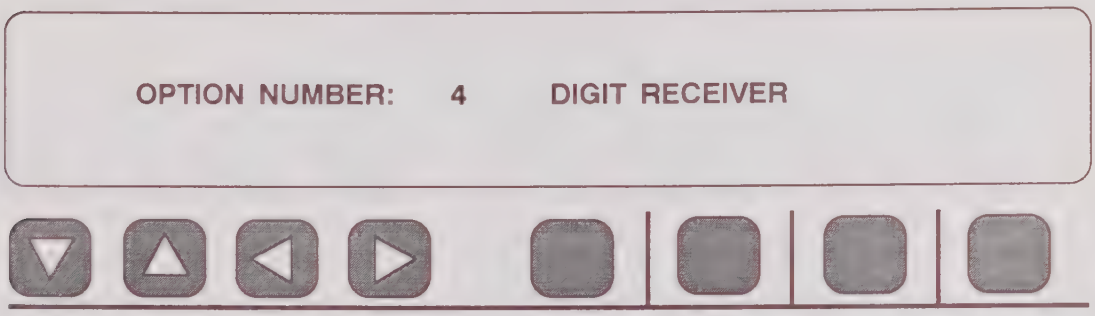
NOTE: To initiate the manual mode the operator must have enabled the Manual Sequence when the 930A display asked for the choice. That set up display is repeated below and shows OFF as the previous condition.



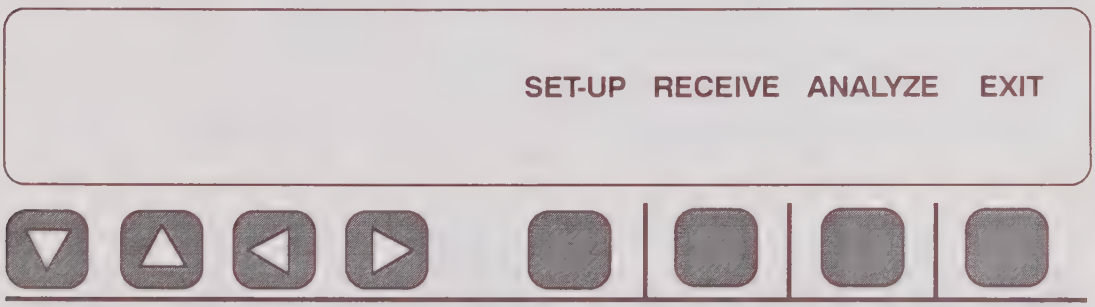
The operator need only press Softkey 3 to enable the Manual Sequence.

4-7.1.1 RESPONDER TESTING FROM THE DIGIT RECEIVER MENU

The user can access the Responder function from the Digit Receiver menus as well. Option 930A-01 Digit Receiver/Analyzer allows the user to set the 930A to be a Type 100, 102 or 105 Test Line after a sequence has been received. To illustrate the operation of this function we must return to Menu Option 4: DIGIT RECEIVER. The 930A display is shown below:



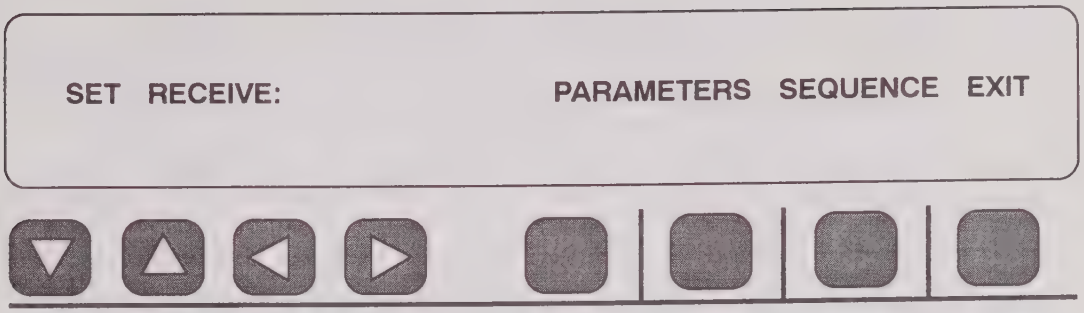
Enter the Digit Receiver menu by pressing any Softkey and the Primary Digit Receiver Set-Up menu will be displayed as shown below:



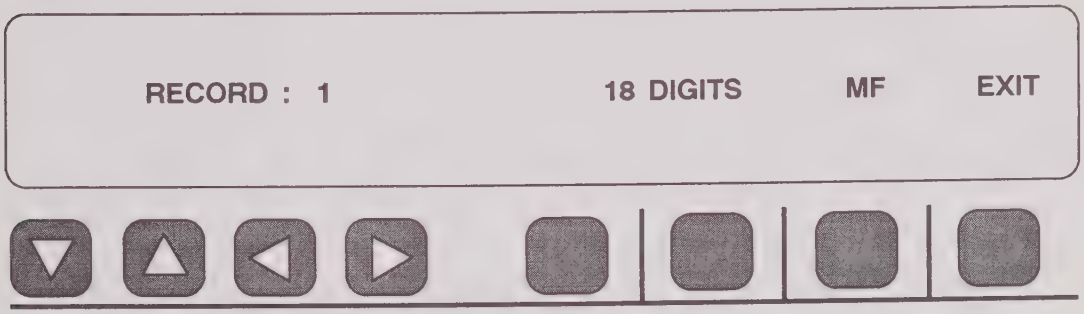
The Digit Receiver must be set up for the expected parameters and supervision on the trunk under test. As a typical example, assume that it is desired that the 930A simulate a Type 105 Test Line after a DTMF sequence has been received on a Wink Start trunk.

The user may refer back to Section 4-2 for further details on setting up the 930A Digit Receiver but for the purposes of this example the following outline should suffice.

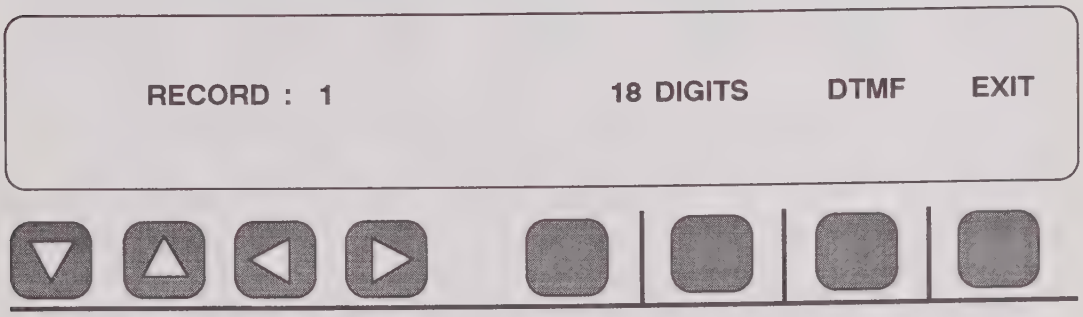
First, in this example, a single DTMF sequence is expected so it is necessary to set the 930A to look for a DTMF sequence. Press Softkey 1 (labeled SET-UP) in the above display and the Set-Up menu will be displayed as shown on the following page.



Press Softkey 1 (labeled PARAMETERS) and the display will change to:

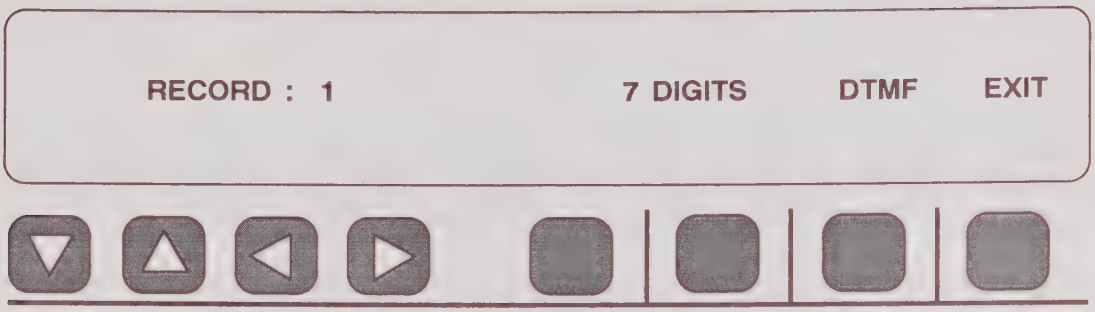


In this case the Parameters for Record 1 are set for MF digits and DTMF is needed. Press Softkey 3 (labeled MF above) until DTMF appears as shown below:



Next, since this is a DTMF sequence, the correct length of the received record must be entered. Assume for this example that the digit string will be that of a local call or 7 digits long (no area code).

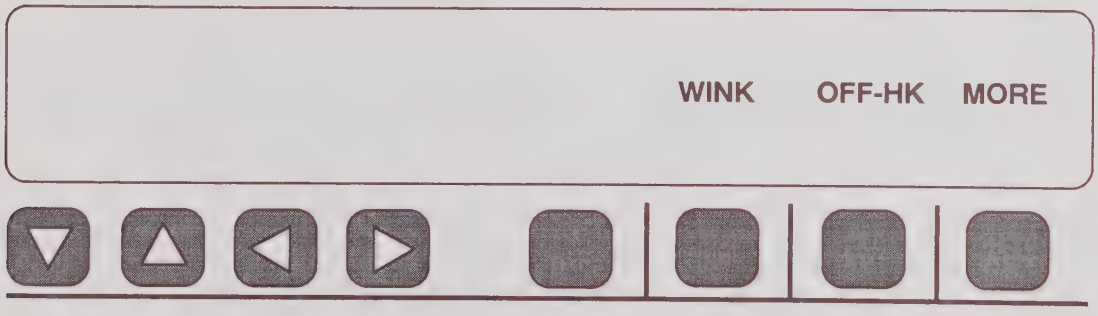
Press 7 and then the ENTER key and the display will read:



Since only a single record is expected (this is not a Multi-Wink example), there is no need to set up records 2, 3 or 4.

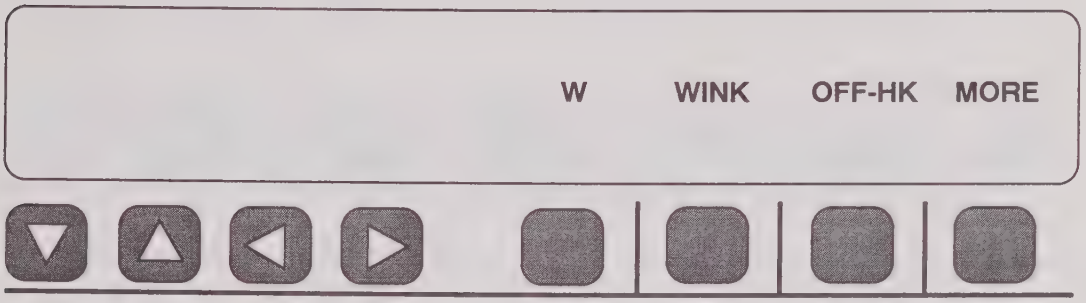
Next, press Softkey 4 (labeled EXIT) to return to the main Set-Up menu shown below:

The next step is to enter the SEQUENCE Set-Up menu. Press Softkey 3 (labeled SEQUENCE above) and the 930A display will become:

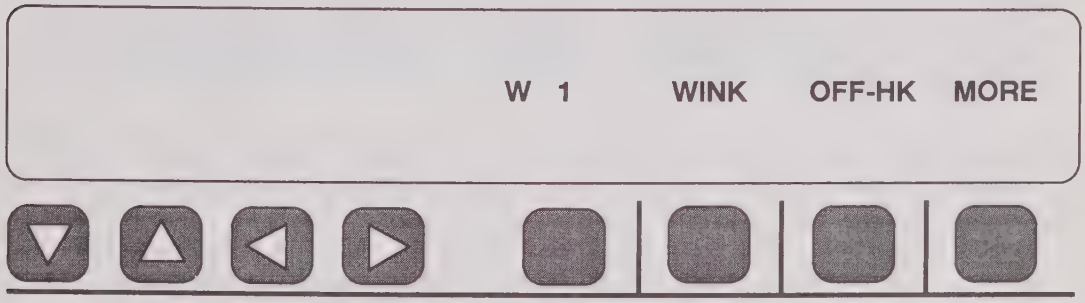


If there is any previously entered sequence present, press the CLEAR key to obtain the above display. Remember that, for this example, a Wink Start trunk was specified and so the first thing which must be done is to tell the 930A to provide a Wink.

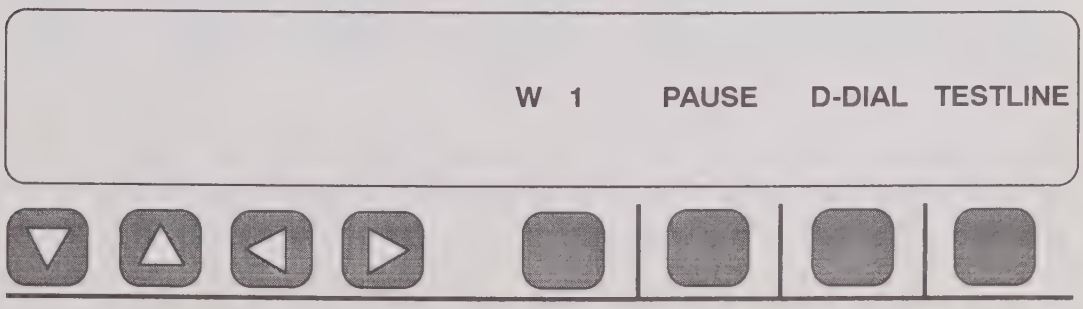
To enter a Wink into the sequence, press Softkey 2 (labeled WINK) and the display will become:

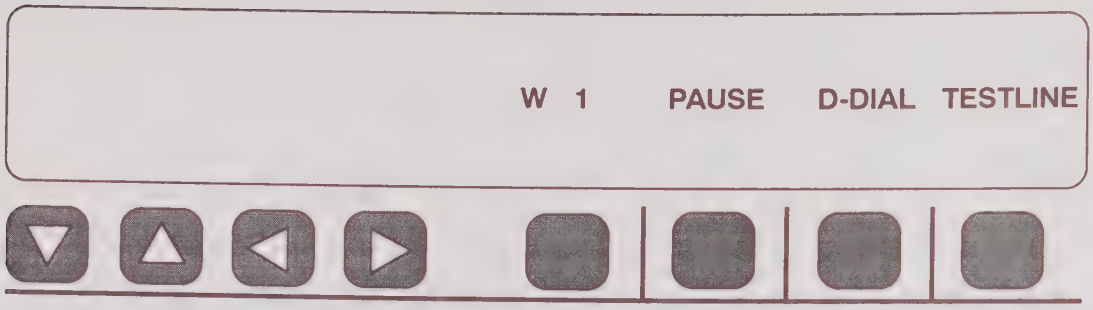


Next, the 930A must be told to receive the record following the wink start. Since only one record is expected (this is not a Multi-Wink sequence example), the next step is to enter a number "1" into the sequence. Press the "1" on the numeric keypad and then press the ENTER key and the display will change to:

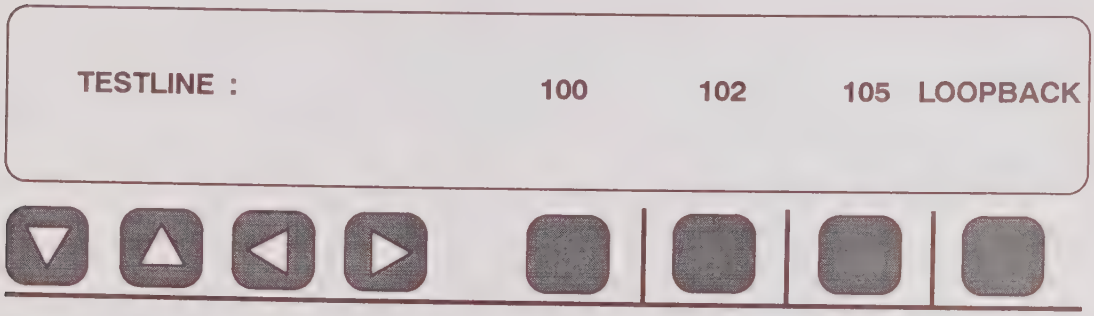


After the record has been received, the 930A is to become a Type 105 Test Line. To accomplish this, press Softkey 4 (labeled MORE) and the 930A display becomes:

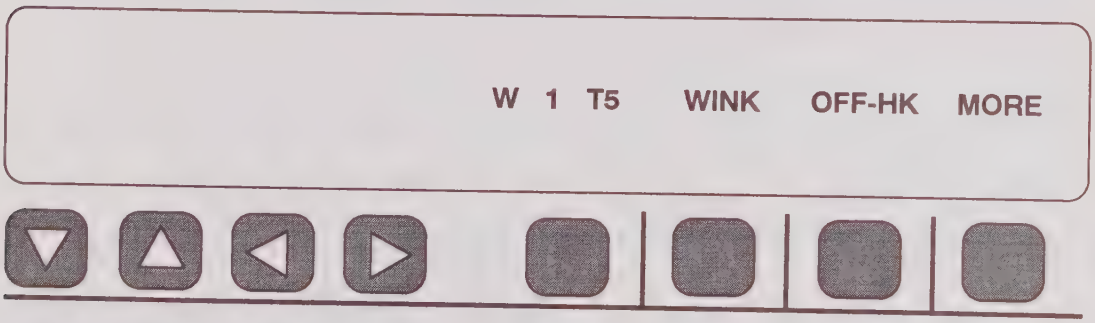




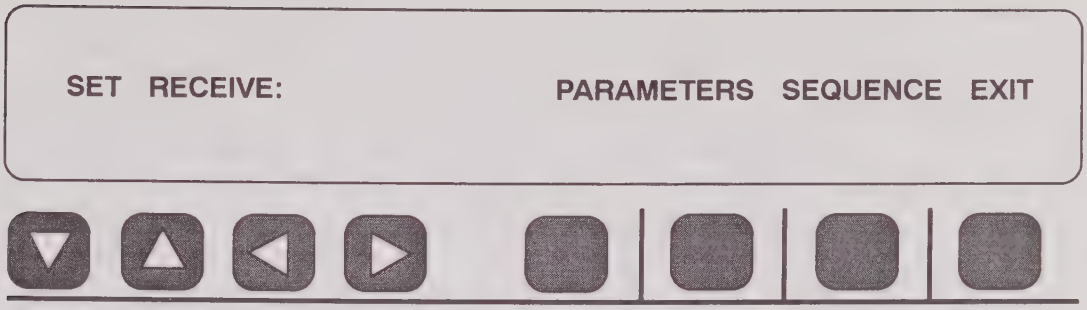
Press Softkey 4 (labeled TESTLINE) and the 930A display will show the following choices:



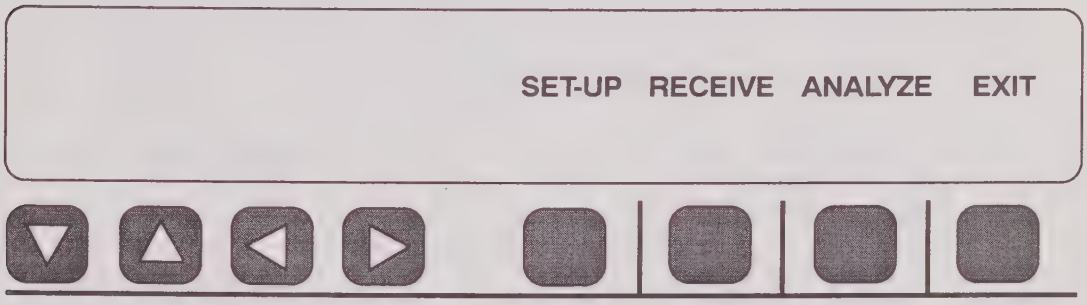
Since it was desired to emulate a Type 105 Responder at the end of the received sequence, press Softkey 3 (labeled 105 above) and the 930A display will show:



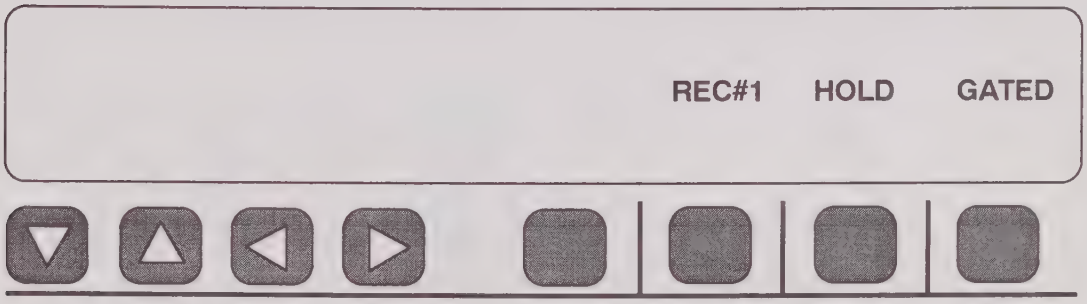
The proper sequence has now been set up. The last step is to place the 930A in the receive mode. Press the OPTION MENU Function key to return to the Set-Up menu shown on the next page.



Press Softkey 4 (labeled EXIT) to return to the primary receiver menu shown below:



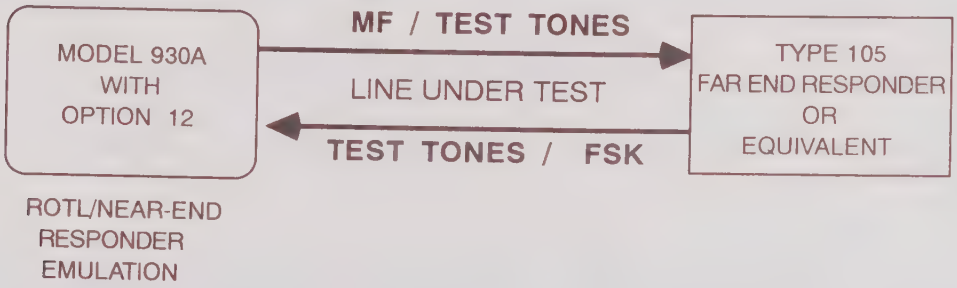
Now press Softkey 2 (labeled RECEIVE) and the 930A will enter the receive digits mode of operation. The 930A display will appear as shown below:



When the 930A sees a seizure of the trunk it will respond with a Wink and then expect to receive a digit string (DTMF digits in this example) which will be displayed across the screen. After the digit string has been received the 930A will emulate a Type 105 Responder until the distant end goes On-Hook.

4-7.2 MENU OPTION NUMBER: 26 ROTL/NEAR-END RESPONDER

With Option 930A-12 installed the Model 930A can also perform the functions of a ROTL/Near-End Responder. In this configuration, the 930A becomes a manual ROTL/Near-End Responder. The far-end responder can be accessed and the 930A supplies the MF signaling necessary to initiate Loss, Gain/Slope, C-message Noise, Noise with Tone, and Return Loss measurements. A typical connection is shown below:



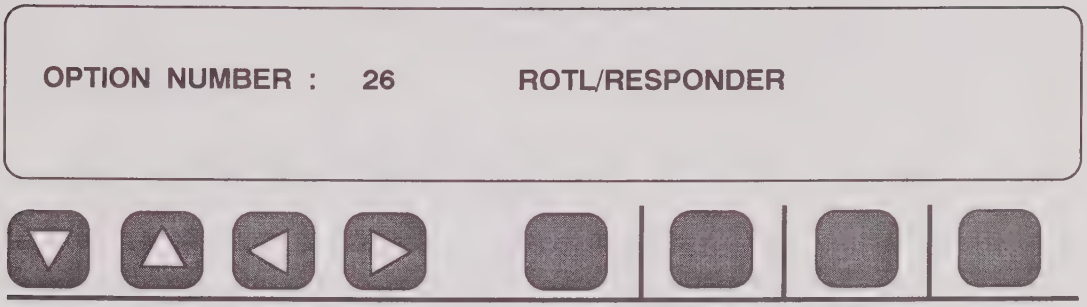
To use the Model 930A as a ROTL/Near-End Responder, perform the following steps to set up the near end unit (it is assumed that a 930A at the far end has been set to Far-End Responder and turned on or that a compatible Far End Responder is in place) :

Press the Option Menu **Option Menu** key.

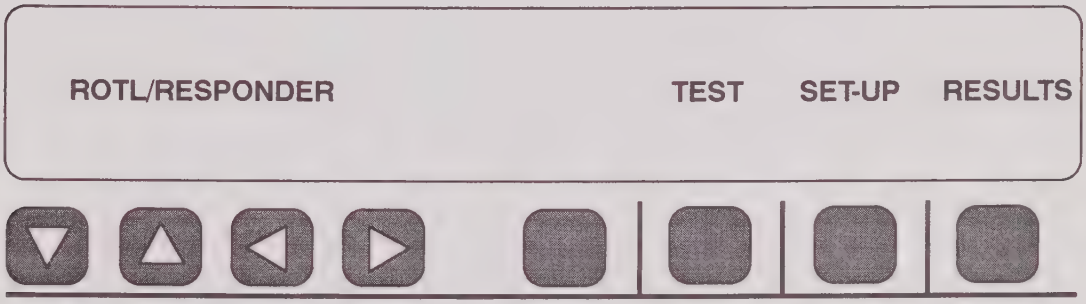
Use the UP/DOWN arrow keys

to select Menu Option 26: ROTL/RESPONDER.

The 930A display will appear as:

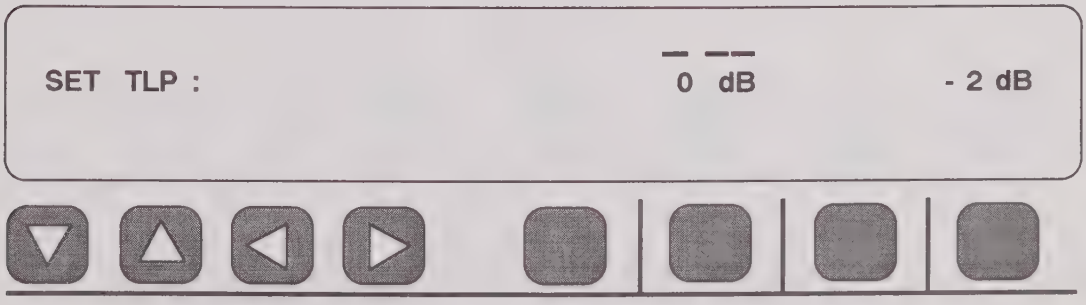


Press any Softkey to enter the option and the 930A display will change to the following:



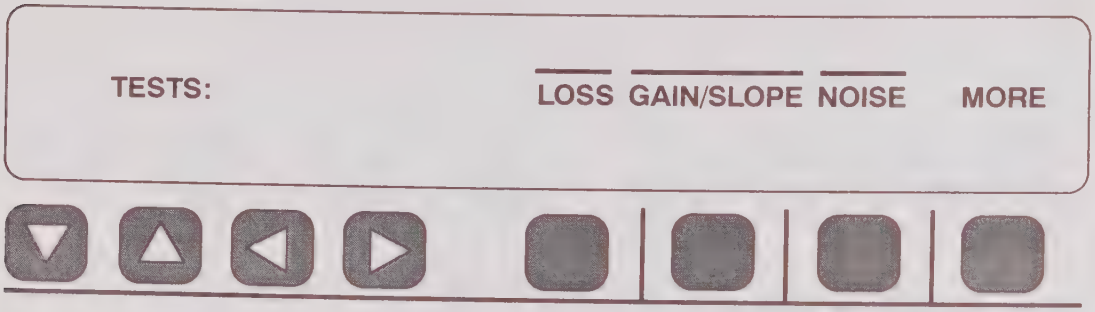
At this point, it is assumed that the operator is going to set up the 930A for the first time. The set-up procedure described need not be repeated unless the operator desires to change settings for some future testing.

To begin, the operator should press Softkey 3 labeled SET-UP. The 930A display will change to:

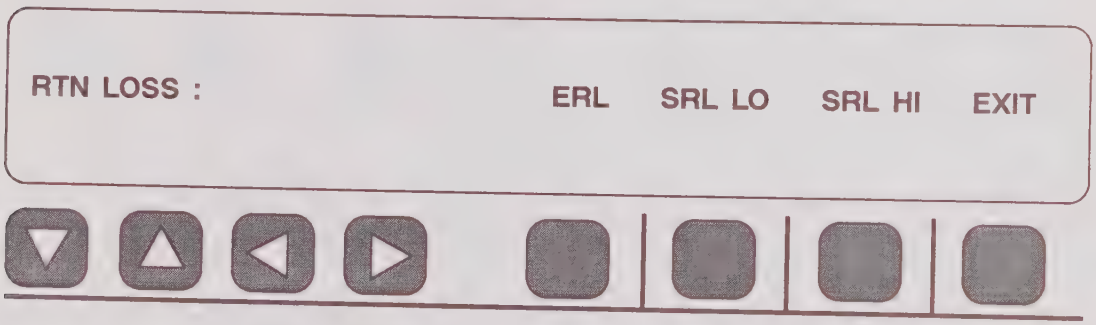


At this point the operator is prompted to select either a 0 dB or a -2 dB Transmission Level Point (TLP). This depends upon the circuit information

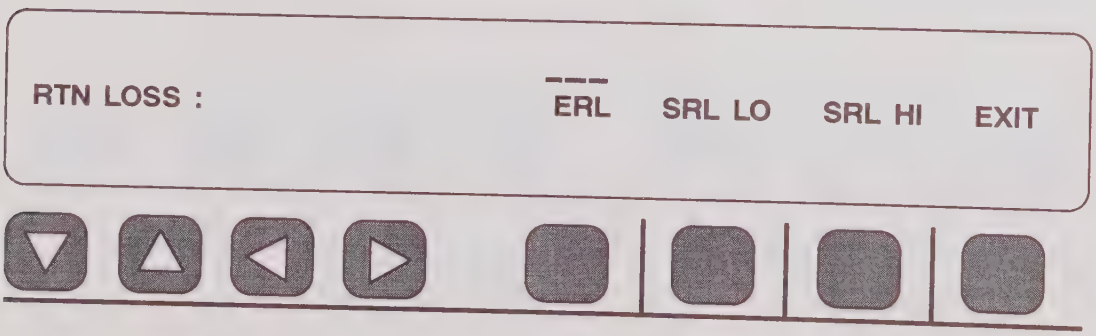
supplied to the operator for the line under test. Press Softkey 2 if the set is connected at a 0 dB point or Softkey 4 if the set is connected at a -2 dB point. The 930A display will then change to:



Tests which have been selected are highlighted, as are all of the above tests. To select or deselect a test simply press the Softkey directly beneath the test. This will toggle between select and deselect. Choose the appropriate state for the type of testing being performed. Pressing Softkey 4 will cause the 930A to display the next series of tests which are:



The operator can now select any or all of the return loss measurements by pressing their associated Softkey. For example, if Echo Return Loss measurement is desired, press Softkey 1 (under ERL) and a cursor will appear over the ERL on the 930A display as shown below:



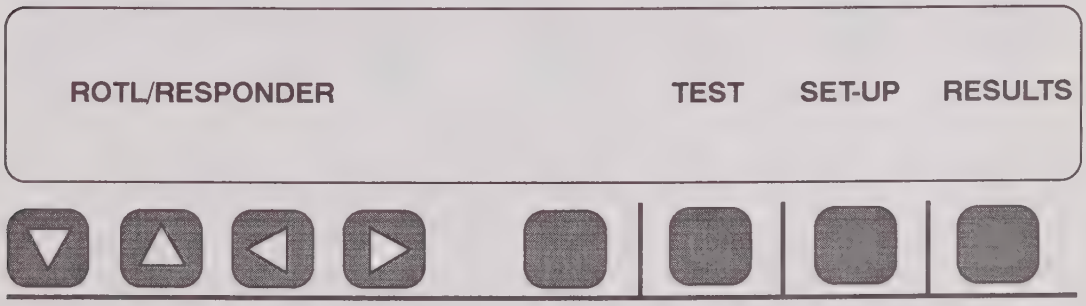
The operator may also select SRL-LO and/or SRL-HI. Return Loss testing is not standard in all far-end responders.

The transmission tests which can be performed by the 930A are briefly described below:

1. LOSS tests the two-way loss at 1004 Hz, 0 dBm.
2. GAIN/SLOPE tests the two-way loss at 404 Hz, 1004 Hz and 2804 Hz. All tone levels are at -16 dBm.
3. NOISE tests C-Message noise in both directions and tests two-way C-Notch noise using a -16 dBm, 1004 Hz holding tone.
4. ERL, SRL-LO and SRL-HI tests the two-way return loss for each of the three types.

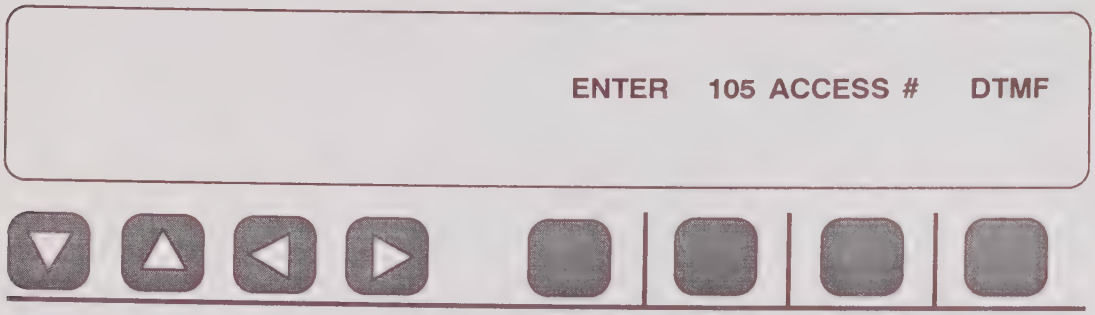
Once the appropriate tests have been selected, the set-up phase of the test procedure is finished. This need not be repeated unless the TLP changes or the types of tests change.

At this point the operator should press Softkey 4 to exit back to the main menu and the 930A display will change back to:



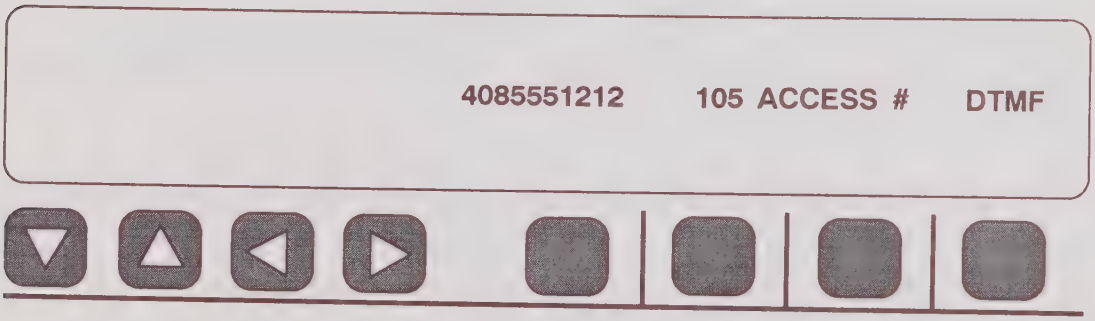
The operator should now press Softkey 2 (labeled TEST) to begin the test procedure. The first thing which must be done is to access the far end 105 test line/responder.

After pressing Softkey 2, the 930A display will change to the following:



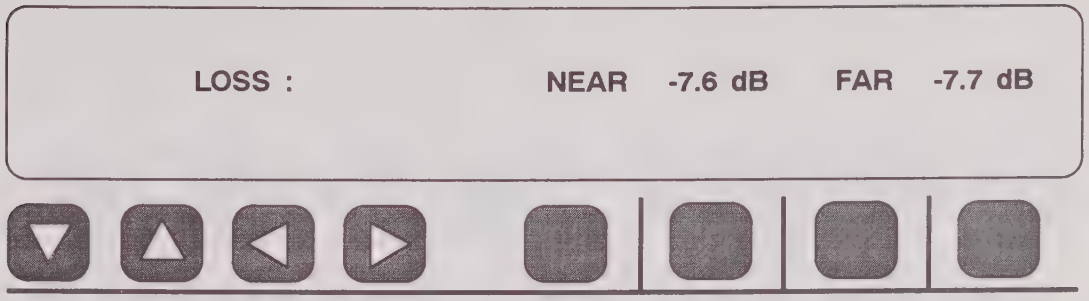
This display prompts the user to enter the access number of the far end test line. The digit sequence may be dial pulse, MF or DTMF. The operator must first select the appropriate type of signaling using Softkey 4. In this example DTMF outpulsing has been selected. The user now enters the number of the far end test line using the numeric keypad.

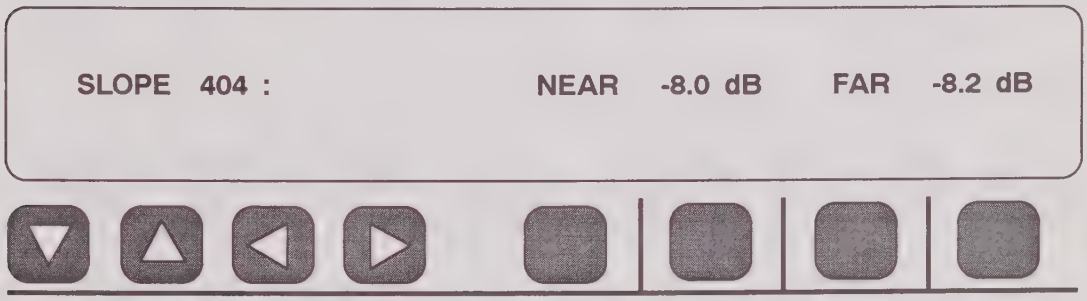
An example of a 105 access number in DTMF is shown below:

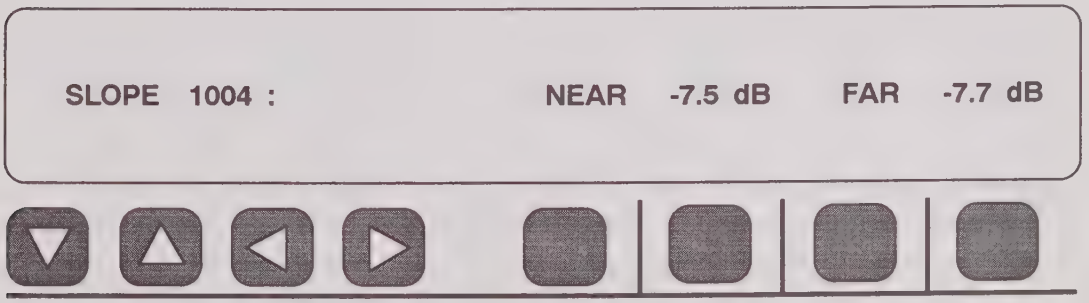


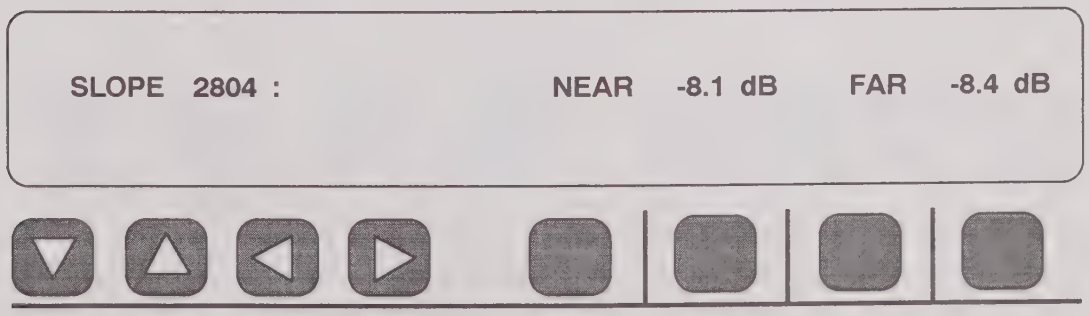
Once the correct number has been entered, the operator need only place the front panel hook switch in the OFF HOOK position to seize the line and outpulse the digit string. When the far end has been accessed, the operator will hear a series of test progress tones as the 930A goes through the series of tests which were programmed. Suppose for this example that the operator had set the 930A to test Loss, Gain/Slope, Noise and Noise with Tone. After outpulsing the digit sequence and accessing the far end test line, a series of displays would be shown on the 930A as it performed each measurement.

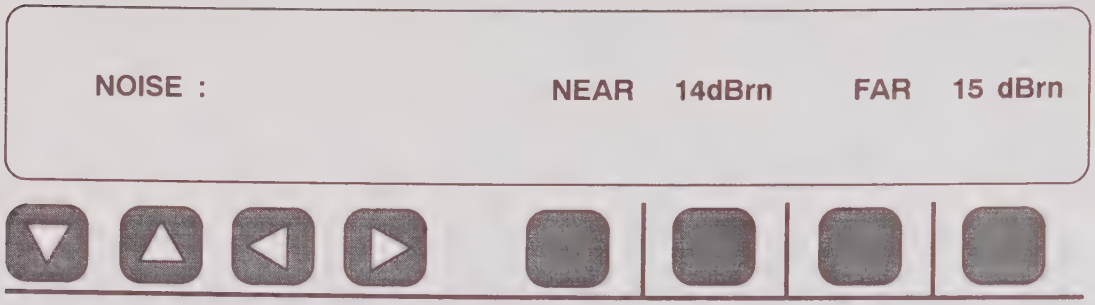
For this example, typical displays might be:

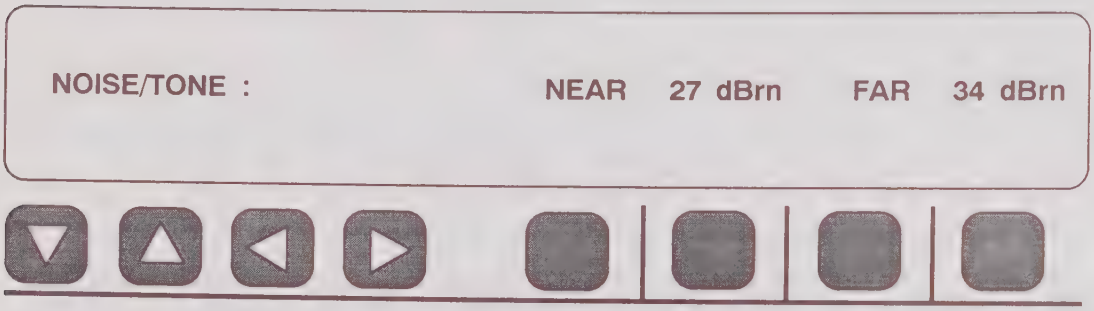






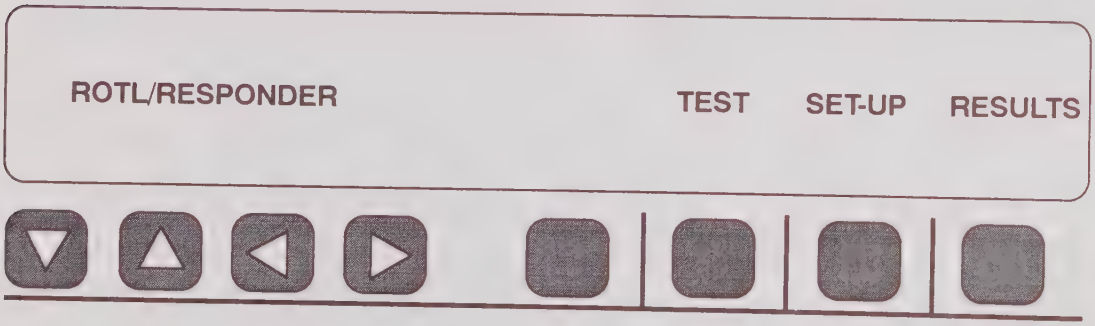






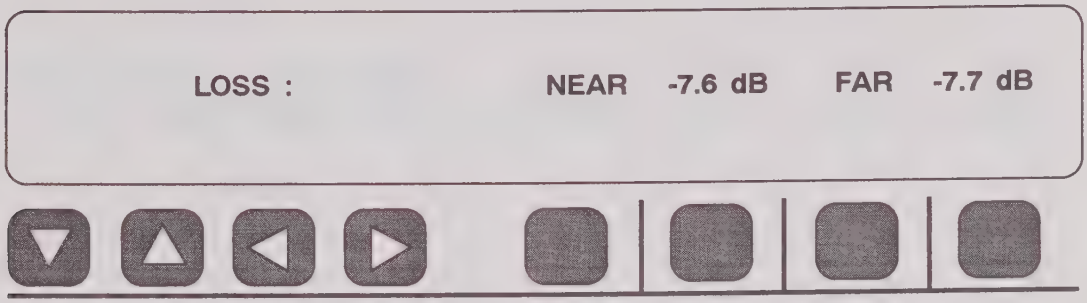
The 930A sequences through these tests and flashes the results briefly. The results are also stored in battery backed CMOS RAM. If a printer is connected, the test results will be printed out as they occur. Once the sequence of tests has been completed the 930A releases the far-end responder.

At this point the 930A automatically returns the operator to its main display as shown below:

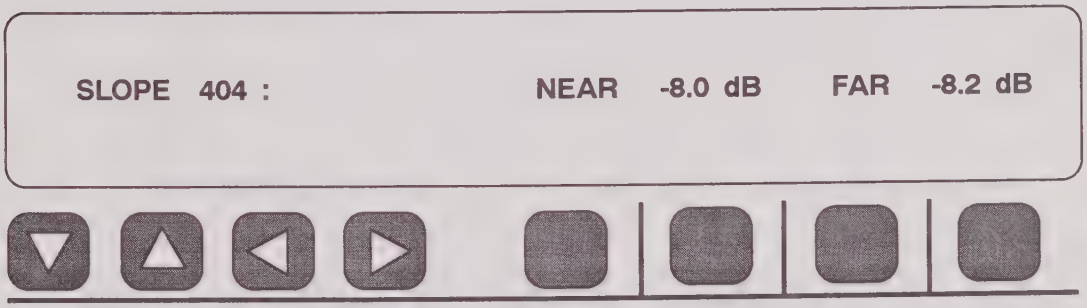


In order to view the results of the tests (which were flashed by at a reasonably rapid rate during testing) press Softkey 4 (labeled RESULTS).

The 930A will recall the stored results of the previous test sequence. In the previous example, after pressing Softkey 4, the LOSS test results would have appeared as:



The operator could then use the UP/DOWN arrow keys or Softkey 1 to scroll through the various test results. For instance, pressing Softkey 1 would bring up:



Continued pressing of Softkey 1 or the arrow keys would enable the operator to review all of the test results in a convenient manner. The results are retained in memory until a new series of tests is begun and the old results are overwritten.

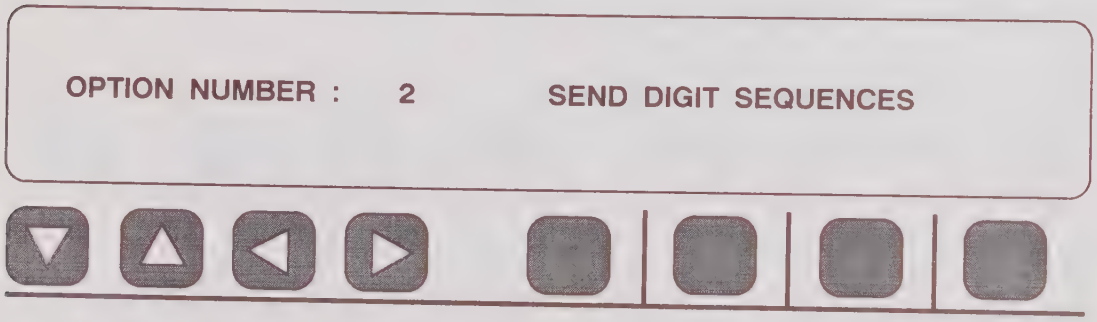
Press the Option Menu Function key or any front panel Function key to return to the main ROTL/RESPONDER menu display.

4-7.2.1 ROTL TESTING FROM THE SEND DIGIT SEQUENCES MENU

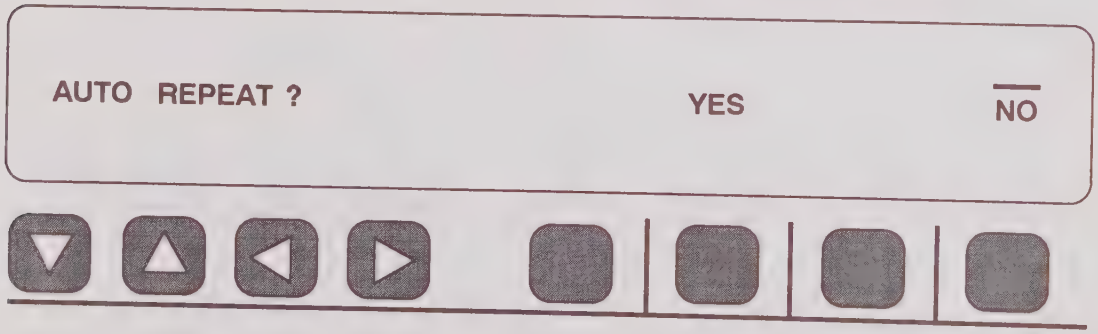
Option 930A-12 also enables the user to operate the manual ROTL test function from the SEND DIGIT SEQUENCES menu. This enables the user to insert Winks or even place a Multi-Wink type call to initiate ROTL testing.

The user should first set up the ROTL/RESPONDER in Menu Option 26 as described in Section 4-7.2. This, at the least, sets the tests which are desired. However, once this has been accomplished, the operator has the choice of sending the Far End Responder's number from the ROTL/RESPONDER menu (no Winks, etc. can be sent from this menu) or going to Menu Option 2: SEND DIGIT SEQUENCES to send it. In some cases, there are points in the telephone network where it is essential to be able to send a Multi-Wink sequence in order to complete a call. In such instances, the user can now place the call to the Far End Responder to initiate testing from the SEND DIGIT SEQUENCES menu.

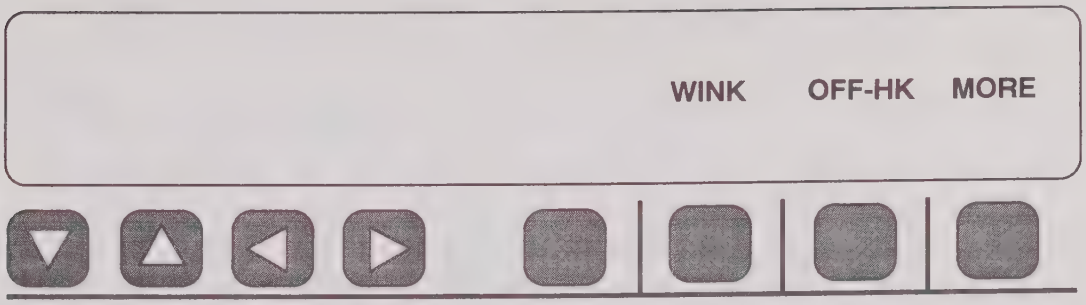
To begin, it is necessary to return to Menu Option 2: SEND DIGIT SEQUENCES. This display is repeated from Section 3-12.2.



Enter the menu by pressing any Softkey and the display becomes:

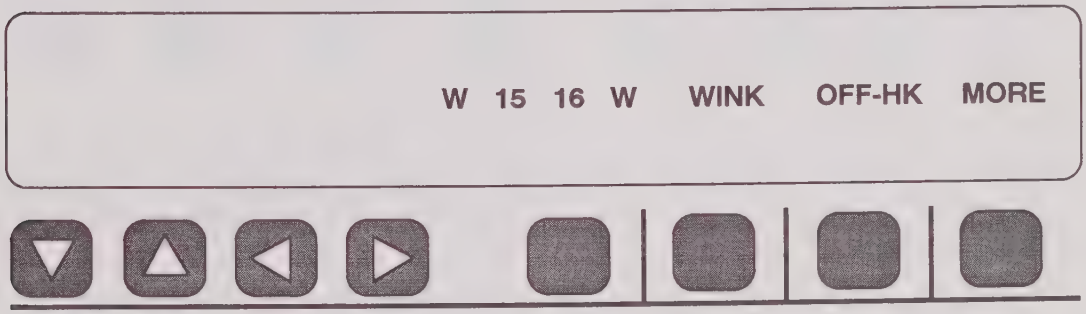


Press Softkey 4 (labeled NO) to send the sequence one time only and the display changes to:

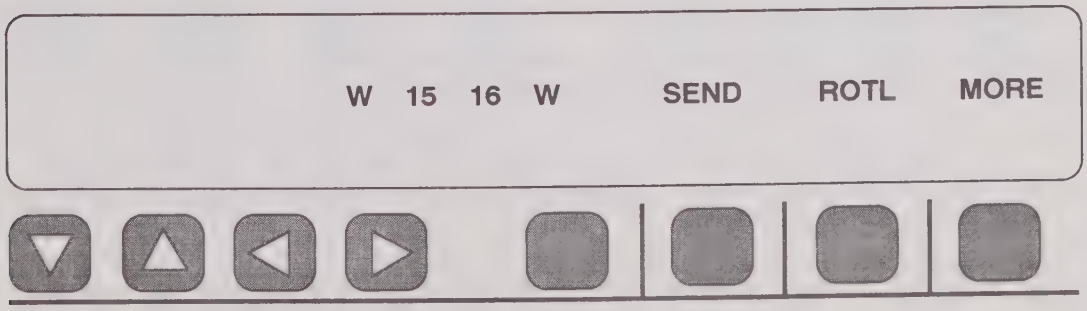


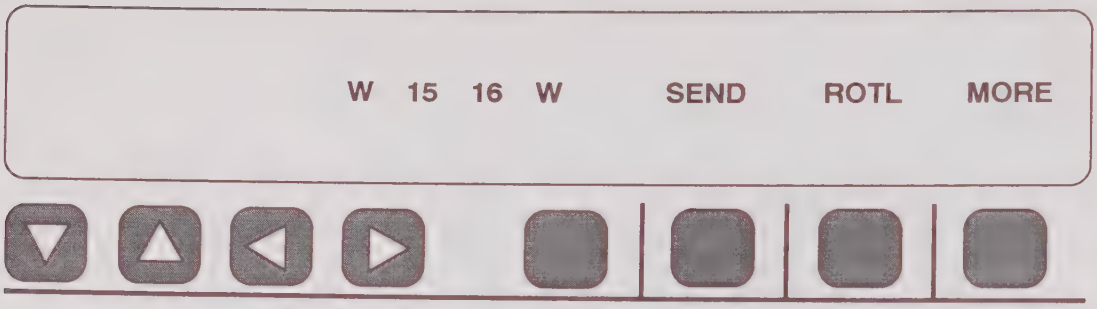
If any previously entered sequences are displayed, press the CLEAR key to obtain the above display.

In this example, assume that, to place the call to the far end responder, it is necessary to simulate an Equal Access sequence. This sequence will consist of two MF records: the ANI or calling number, and the called number. Assume further that these two numbers have been stored in memory locations 15 and 16 using the procedure outlined in Section 3-12.2. The 930A display, after entering the winks and the two numbers would be:

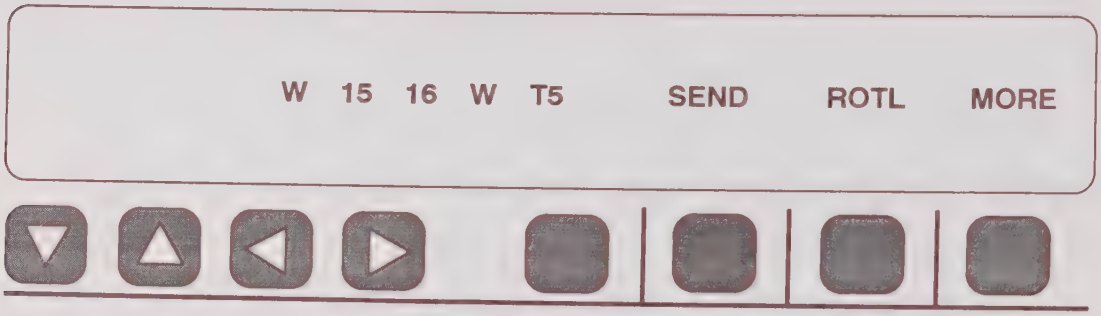


After entering the Feature Group D sequence, the next step is to tell the 930A to become a manual ROTL/ Near End Responder so that it will commence testing after the call completes. To accomplish this, press Softkey 4 (labeled MORE) until the 930A display shows:

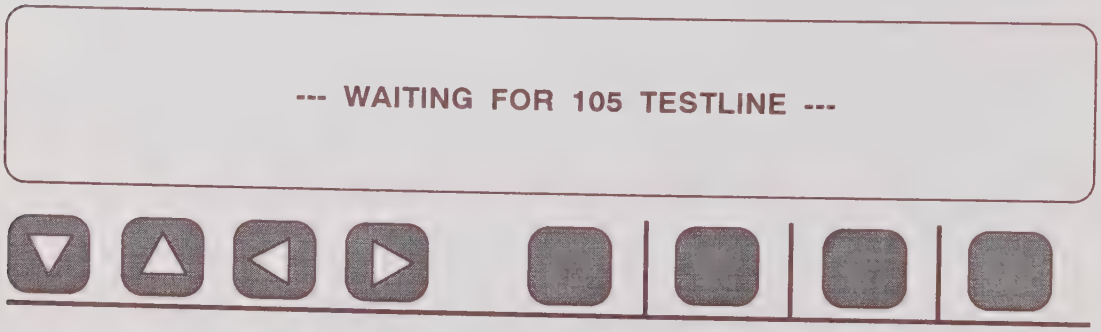




It remains to place the ROTL function at the end of the sequence by pressing Softkey 3 (labeled ROTL) and the 930A display will become:



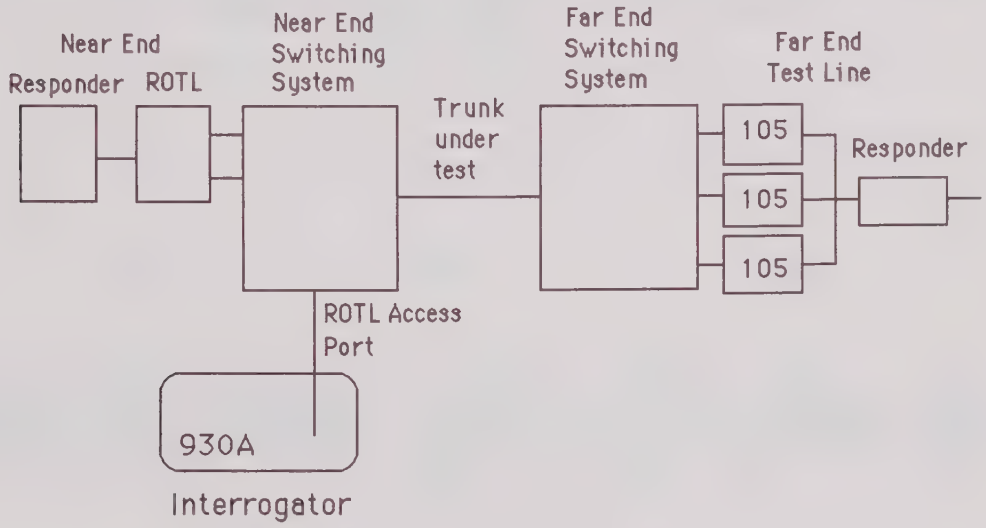
In order to initiate testing, the user need only place the front panel Hook Switch in the OFF-HOOK position and the 930A will outpulse the sequence. The 930A display will appear as follows until the call completes and testing begins:



When testing commences, the display will change to indicate the two-way test results as described in Section 4-7.2.

4-7.3 MENU OPTION NUMBER: 27 ROTL INTERROGATOR

The ROTL Interrogator portion of purchased option 930A-12 allows the operator to command a ROTL from a ROTL access port or over a dial-up line. The 930A supports two-way transmission testing to type 105 test lines and one-way transmission testing to type 100 and 102 test lines. Operational and balance and long term (BALT) tests can also be performed, but support for these tests is limited to the return of audible tones to the operator. A typical test line arrangement showing the 930A as a ROTL Interrogator connected to the near end switch ROTL access port is shown below.



INTERROGATOR CONNECTED AT ROTL ACCESS PORT
FIGURE 4-16

The Model 930A could also be used as an Interrogator over a dial-up line or it could gain access to a particular channel of a T-1 bit stream at the DSX and work as an Interrogator from that point. Generally speaking, the ROTL access port of a switch is occupied by the CAROT controller which means that the operator will likely be using the 930A over dial-up or T-1 facilities.

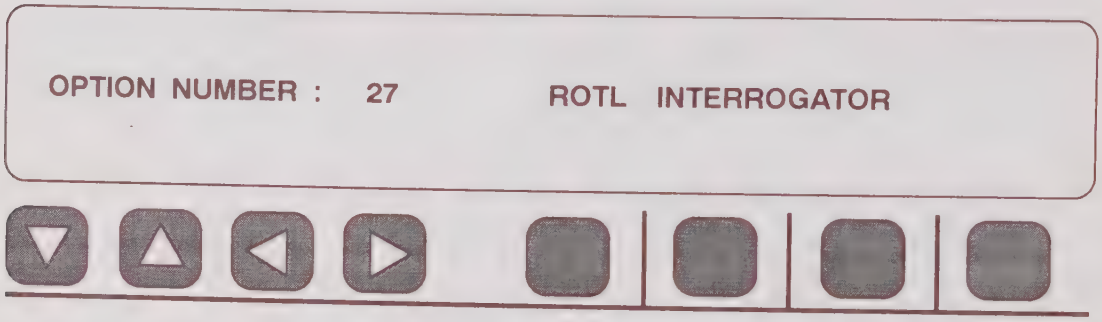
When configuring the Model 930A as a ROTL Interrogator, it is necessary to select the appropriate Trunk Type (Refer to Section 3-6) before connecting the 930A to either the ROTL access port, the dial-up line, or the DSX (Select the Trunk Type for the connection between the 930A and the ROTL, not the line under test). Once this has been accomplished, the operator may proceed to set up the 930A as a ROTL Interrogator by performing the following steps:

Press the Option Menu **Option Menu** key.

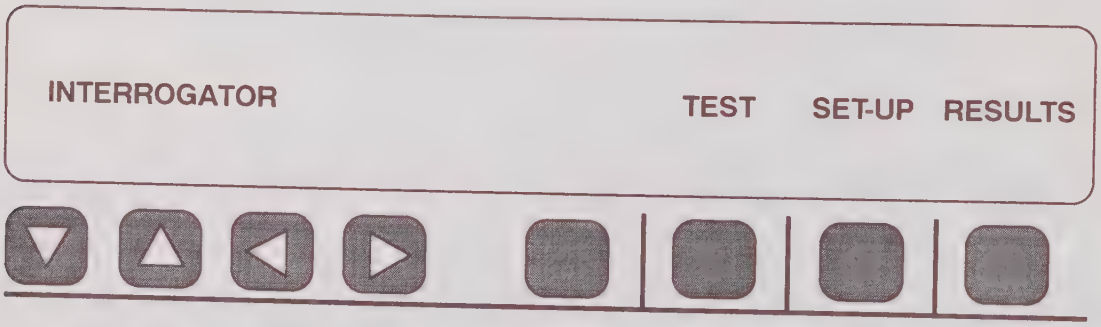
Use the UP/DOWN arrow keys

to select Menu Option 27: ROTL INTERROGATOR

The Model 930A display will appear as follows:



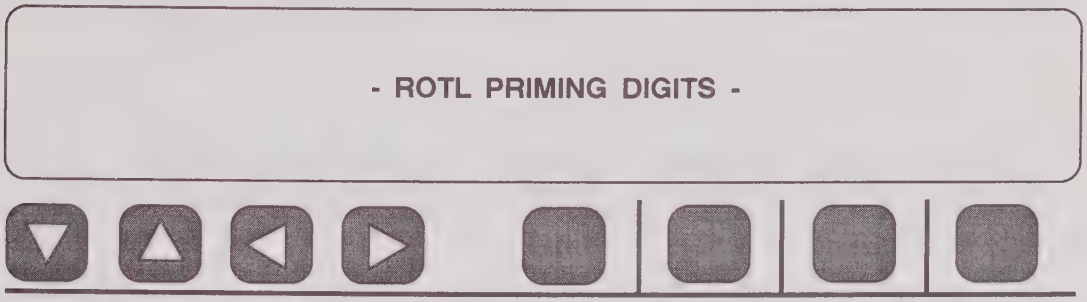
Press any Softkey and the display becomes:



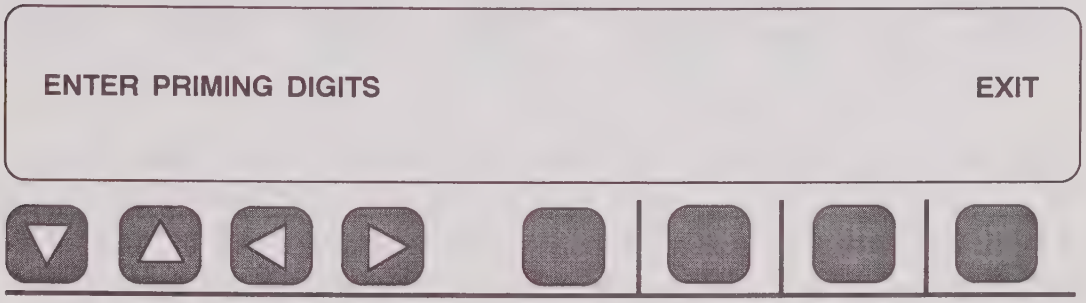
For purposes of description, it is assumed that the operator desires to set up the 930A for the first time. Remember that the set up parameters will be retained in non-volatile memory so that this step need not be repeated unless it is desired to change the set-up.

4-7.3.1 ROTL PRIMING DIGITS SET-UP

To begin, the operator should press Softkey 3 labeled SET-UP. The 930A display will then briefly flash the following:



If no priming digits have been entered previously, the display will then prompt the user by showing the following:



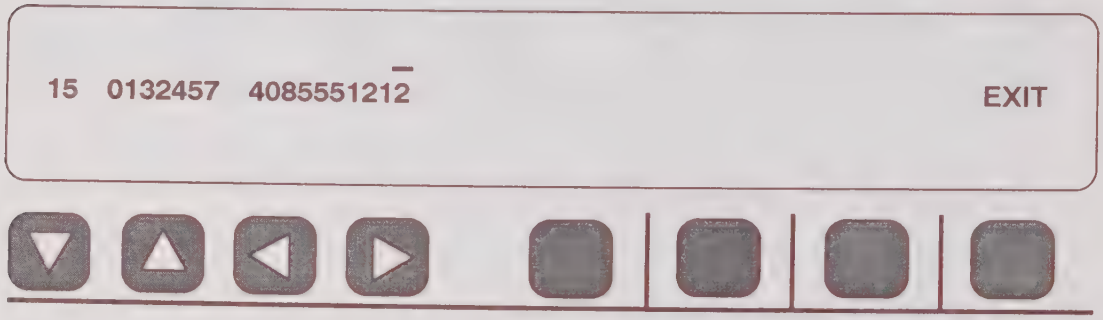
If priming digits had previously been entered, as would normally be the case, then the last string of priming digits would have been displayed instead of the words "ENTER PRIMING DIGITS". If an unwanted string of digits were present, they could easily be removed by pressing the CLR key. New ROTL priming digits may now be entered by using the numeric keypad. First, however, it is necessary to say a few words about ROTL priming digit sequences and how the 930A displays them.

IMPORTANT NOTE:

ROTL priming digits are always MF digits and so the 930A has been set up to automatically insert the KP and ST delimiters. The operator need insert only the actual numerical digits. The 930A will append the KP and ST prior to outpulsing the sequence. This is a deviation from the way in which the DIAL/RING Function operates and was done for user convenience in this option.

Up to thirty (30) digits may be entered in the ROTL priming digits field. These digits consist of the Test Type (up to 3 digits long), the Trunk Identification Number (up to 7 digits long) and the Far End Test Line number (up to 11 digits long). The 930A allows the operator to enter blank characters between the groups for readability. These blank characters are inserted by the UP arrow key and have no effect on outpulsing.

A typical 930A display of ROTL priming digits with blank spaces inserted to separate the groups might appear as shown below:



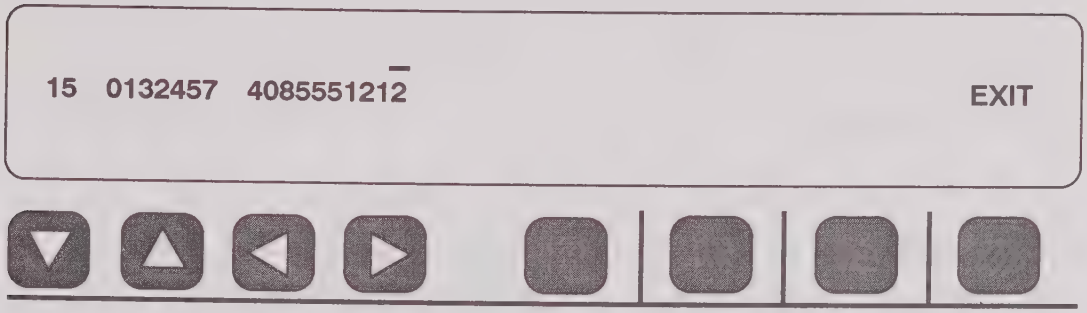
In this example, the first two digits identify the Test Type (Transmission Test with Busy Override using a 105 Type test line in this case), the second group of 7 digits might be the Trunk Appearance Number (TAN) of a No. 4 ESS for example, and the last group is an example of a Far End Test Line number.

ROTL priming digit sequences vary in accordance with the type and vintage of switching equipment, the type of testing to be performed, the test lines available and their manufacturer. Tables of Priming Digit Formats for recent AT&T switches and for Northern Telecom, GTE and ITT switches are provided at the end of this section.

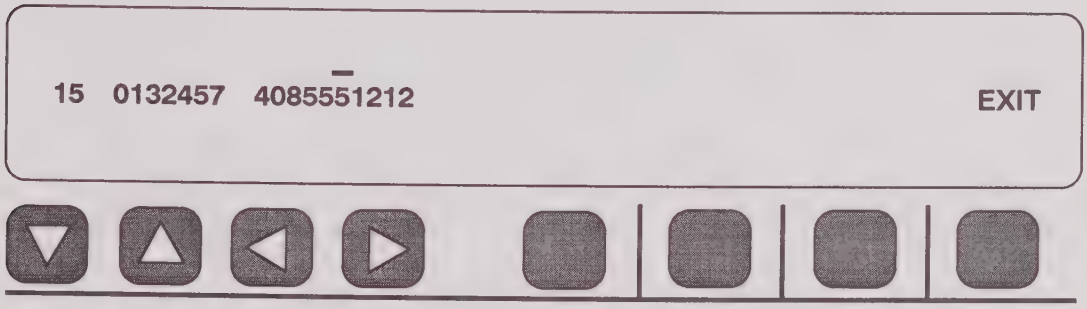
In order to facilitate ease of use, the 930A gives the operator limited editing capability to insert or delete individual characters, rather than having to clear the screen and reenter the entire string if a mistake or an omission has occurred. The LEFT and RIGHT arrow keys move the cursor around the display. The UP arrow key inserts a blank space. The DOWN arrow key deletes an unwanted digit.

Before going on to the next step, let us assume that a mistake has been made in the ROTL priming digit sequence shown above. The following will illustrate the procedure for changing a single character.

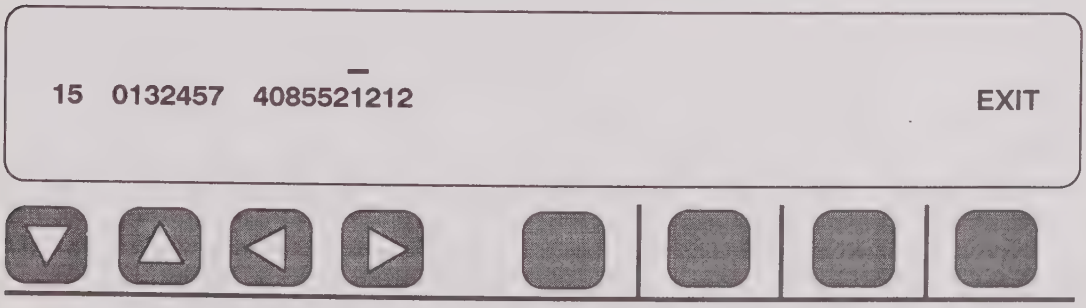
The following display contains a ROTL priming digit sequence that is in error.



Assume that the Far End Test Line number was incorrect and that instead of 4085551212 it should have been 4085521212. Using the LEFT Arrow key, scroll the cursor back over the incorrect digit as shown below:



Now simply overwrite the character in error by pressing the '2' on the numeric keypad and the display will appear as:

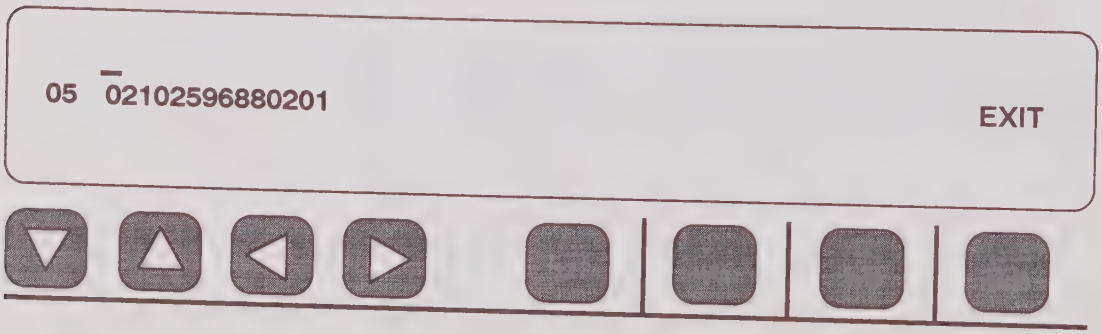


Next, suppose that a ROTL Priming Digit sequence had been input in the following form without any separating spaces.

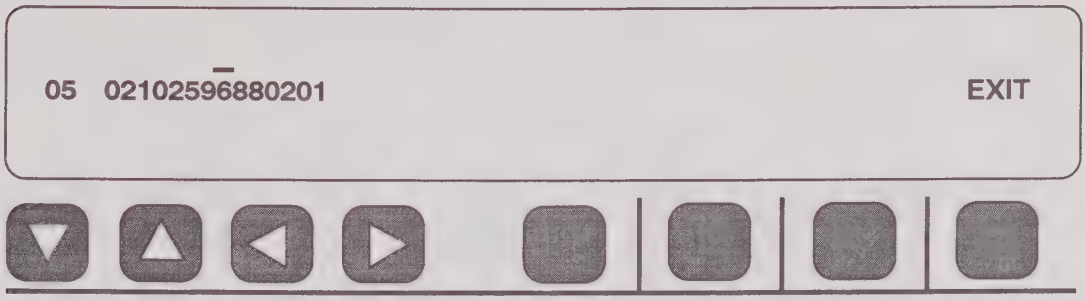
The operator now desires to separate the fields to make it more readable and also add in the area code of the far end responder. To accomplish this, the following steps must be performed.

First, use the LEFT Arrow key to move the cursor to the point at which it is desired to insert a space as shown below:

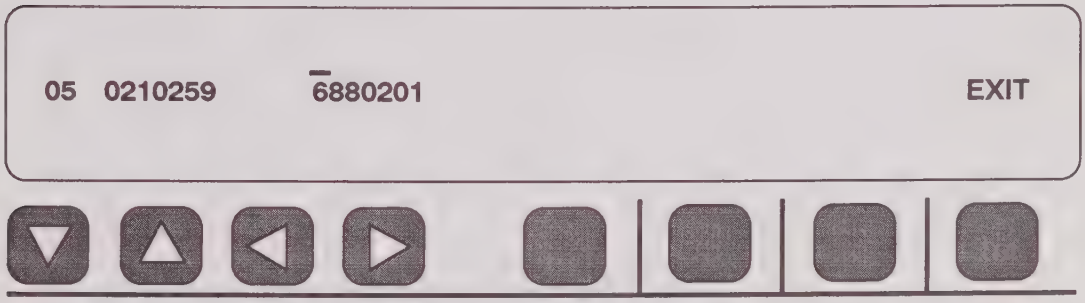
To insert a blank space, simply press the UP Arrow key and a space will be inserted where the cursor was and the other characters will be moved one space to the right as shown below:



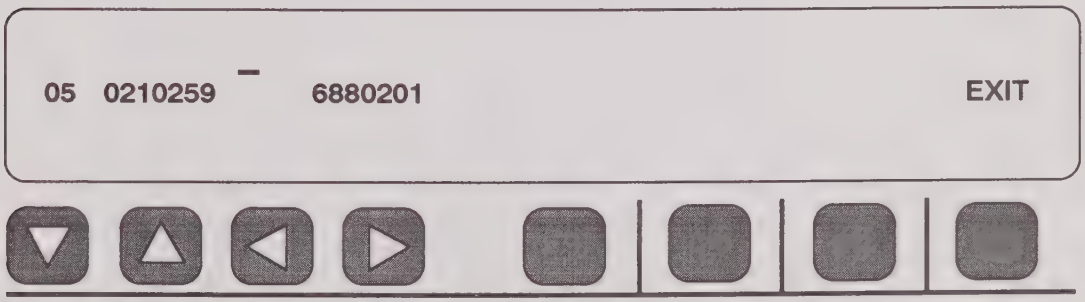
Next, use the RIGHT Arrow key to move the cursor over the number 6 where it is desired to insert a space plus the missing area code for a total of four characters (1 blank plus 3 numbers). The 930A display appears as:



Press the UP Arrow key four times to insert four blank spaces. The display will appear as shown below.

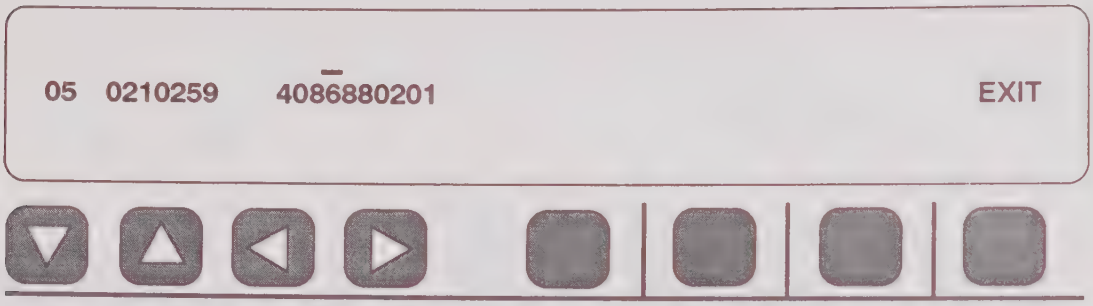


Now move the cursor back three places using the LEFT Arrow key and the display will be:



The operator may now insert the three digit area code which for example purposes will be assumed to be '408'.

Using the numeric keypad, the numbers '4', '0' and '8' are pressed sequentially and the 930A display becomes:



To sum up the editing features of the 930A: The LEFT and RIGHT arrow keys move the cursor. The UP arrow key inserts a blank space. The DOWN arrow key deletes an unwanted digit.

The following Tables contain ROTL Priming Digits for Transmission tests of various switching systems in common use. These Tables are not intended to be complete lists of all ROTL Priming Digits for all types of tests such as Terminal Balance, Connection Appraisal, etc. They are intended for two-way Transmission Tests.

TABLE 4-4
STEP-BY-STEP OFFICE MINI-ROTL PRIMING DIGIT FORMAT

TEST TYPE	TEST LINE	DIGITS																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TRANSMISSION TESTS	100	0	0	0	TRUNK ID			NOTE	FAR END TESTLINE NUMBER										
	102	0	2	0															
	105	0	5	0															

NOTE: The seventh digit depends upon the Trunk Type

DIGITS	TRUNK TYPE
0	Dial Pulse on Loop Supervision Trunk
1	Dial Pulse on Loop Supervision with Stop Dial
2	Dial Pulse on Simplex Supervision Trunk
3	Dial Pulse on Simplex Supervision with Stop Dial
4	MF Signaling on Loop Supervision Trunk
5	MF Signaling on Simplex Supervision Trunk

TABLE 4-5
STEP BY STEP OFFICE EXPANDED FORMAT

TEST TYPE	TEST LINE	DIGITS																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TRANSMISSION TESTS	100	0	0	TRUNK ID				NOTE	FAR END TESTLINE NUMBER										
	102	0	2																
	105	0	5																
TRANSMISSION TESTS WITH BUSY OVERRIDE	100	1	0																
	102	1	2																
	105	1	5																

NOTE: The seventh digit depends upon the Trunk Type

DIGITS	TRUNK TYPE
0	Dial Pulse on Loop Supervision Trunk
1	Dial Pulse on Loop Supervision with Stop Dial
2	Dial Pulse on Simplex Supervision Trunk
3	Dial Pulse on Simplex Supervision with Stop Dial
4	MF Signaling on Loop Supervision Trunk
5	MF Signaling on Simplex Supervision Trunk

TABLE 4-6
NO. 1 ESS ROTL PRIMING DIGITS FORMAT

TEST TYPE	TEST LINE	DIGITS			
		1 2	3	4 5 6 7 8 9	10 11 12 13 14 15 16 17 18 19 20
TRANSMISSION TESTS	100 102 105	0 0 0 2 0 5	NOTE	TRUNK NETWORK NUMBER	FAR-END TEST LINE NUMBER
TRANSMISSION TESTS WITH BUSY OVERRIDE	100 102 105	1 0 1 2 1 5			

NOTE: The third digit is a modifier digit:
1) 0 = Local originating mode.
2) 1 = Tandem 1 (2-Wire tandem configuration with transformers).
3) 2 = Tandem 2 (4-Wire to 2-Wire tandem configuration without transformers).

TABLE 4-7
NO. 4 ESS ROTL PRIMING DIGITS FORMAT

TEST TYPE	TEST LINE	DIGITS		
		1 2	3 4 5 6 7 8 9	10 11 12 13 14 15 16
TRANSMISSION TESTS	100 102 105	0 0 0 2 0 5	TRUNK ID FOR TRUNK APPEARANCE NUMBER	FAR END TESTLINE NUMBER
TRANSMISSION TESTS WITH BUSY OVERRIDE	100 102 105	1 0 1 2 1 5		

TABLE 4-8
GTD-5, ITT 1210 PRIMING DIGITS FORMAT

TEST TYPE	TEST LINE	DIGITS																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TRANSMISSION TESTS	100 102 105	0 0 0	0 2 5	NOTE 1	NOTE 2			NOTE 3			FAR-END TEST LINE NUMBER										
TRANSMISSION TESTS WITH BUSY OVERRIDE	100 102 105	1 1 1	0 2 5																		

NOTE 1: The third digit is a modifier:
1) 0= Talk tandem Off-Hook state without a transformer in the talk path.
2) 1= Talk tandem Off-Hook state with a transformer in the talk path.

NOTE 2: Three digit Trunk Group Number

NOTE 3: Three digit Trunk Group Member Number

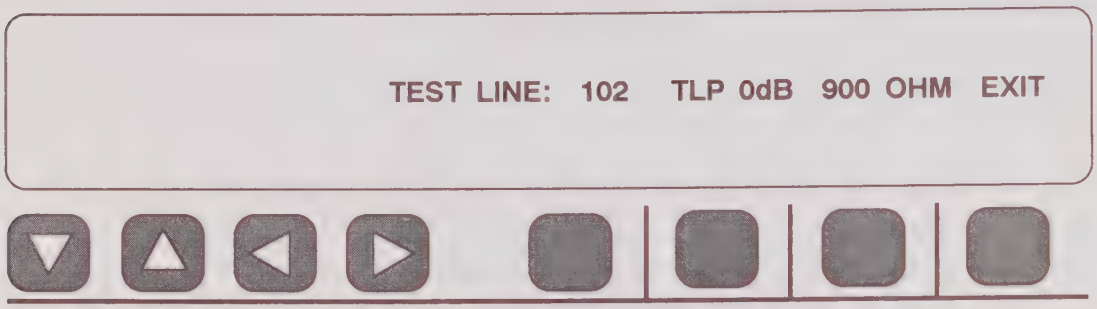
TABLE 4-9
DMS 100/200 ROTL PRIMING DIGITS FORMAT

TEST TYPE	TEST LINE	DIGITS																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
TRANSMISSION TESTS	100 102 105	0 0 0	0 2 5	TRUNK GROUP NMBR				TRUNK GROUP MEMBER NUMBER				NOT SENT TO DMS 100/200			FAR END TESTLINE NUMBER							
TRANSMISSION TESTS WITH BUSY OVERRIDE	100 102 105	1 1 1	0 2 5																			

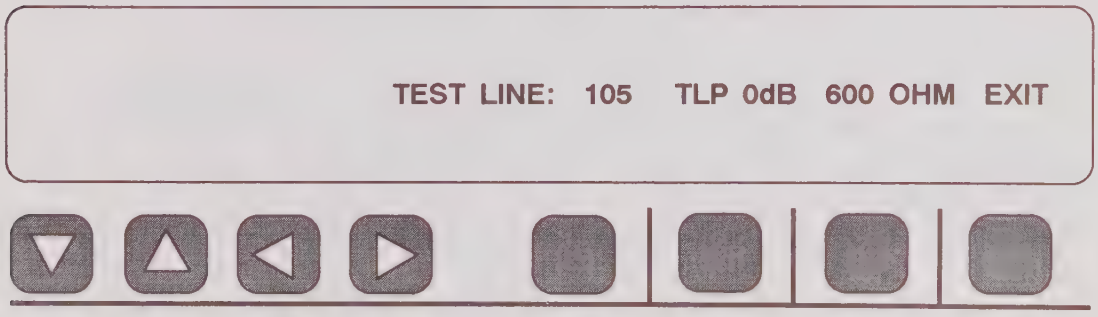
4-7.3.2 RESPONDER CONDITIONING SET-UP

The discussion of the operation of the Interrogator function can now proceed. For example purposes, assume that the ROTL Priming Digits sequence shown above is now the correct sequence for the set-up.

Press Softkey 4, labeled EXIT, in the ROTL Priming Digits display and the 930A will advance to the responder conditioning set-up display. This display, for example purposes, may appear as shown below:



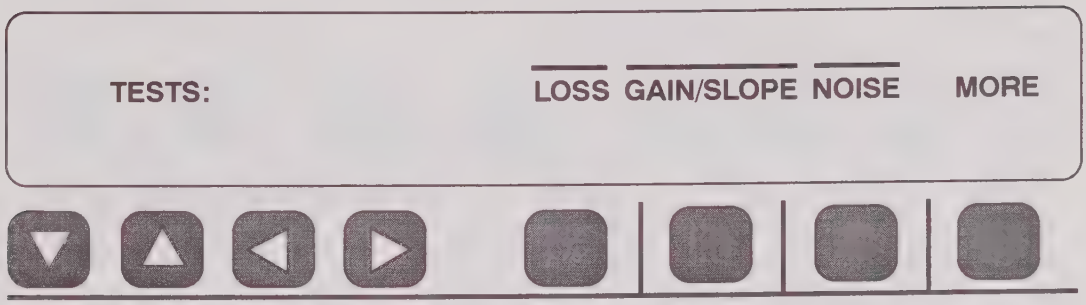
Softkey 1 selects the type of far end test line the ROTL will be calling. The choices are type 100, 102 or 105. Softkey 2 selects the Transmission Level Point (TLP) at which the near end responder will operate. The choices are 0 dB or -2 dB. Softkey 3 selects either 600 ohm or 900 ohm impedance for the trunk under test. For this example, assume that the far end test line is a type 105 and the trunk under test is a 600 ohm circuit. The TLP is 0 dB. To change the set-up shown above, press Softkey 1 until the test line type shows ' 105 '. Press Softkey 3 to change from 900 to 600 ohms. The 930A display now appears as:



The information in this field is used to calculate the conditioning digit sent to the near end responder during transmission testing. If operational or balance testing is being performed this field may be ignored. When the information is correct, press Softkey 4 labeled EXIT to move on to the test selection set-up display.

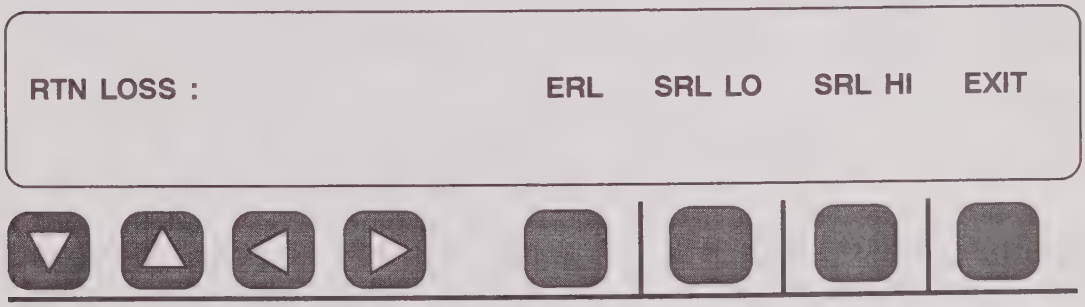
4-7.3.3 INTERROGATOR TEST SELECTION

The test selection display is shown below:



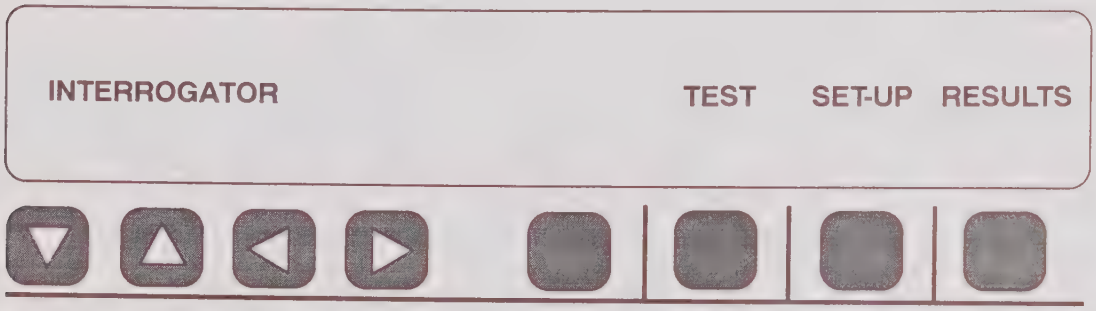
Tests which have been selected are highlighted, as are all of the above tests. To select or de-select a test simply press the Softkey directly beneath the test. This will toggle between select and de-select. Choose the appropriate state for the type of testing being performed. For instance, for two way transmission testing (type 105), the tests would be selected. However, if balance or operational testing was being performed all of the transmission tests would be de-selected. Press Softkey 4 labeled MORE to continue the selection process.

Pressing the MORE Softkey brings up the following display on the 930A:



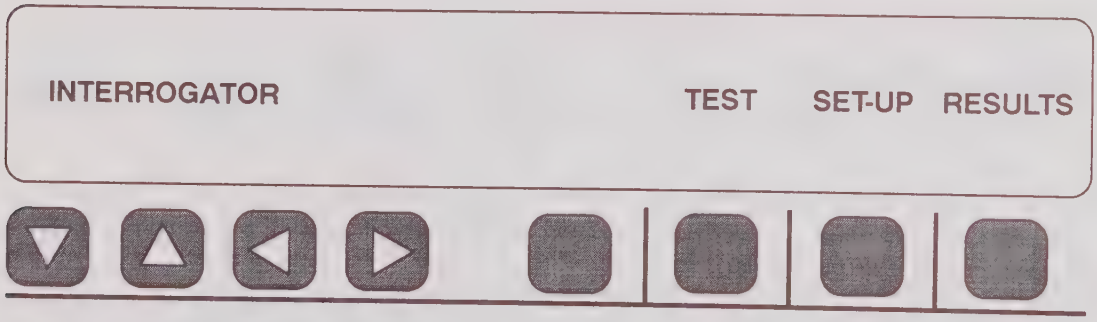
Notice that none of the return loss tests have previously been selected in the above example. It should be noted that many responders do not support return loss testing or support only Echo Return Loss (ERL). For this example, assume that the type 105 far end responder being accessed only has ERL capability. In this case, press Softkey 1 labeled ERL to select ERL testing and leave the other return loss tests de-selected. The 930A display will be:

The set-up of the Interrogator function is now complete and the operator need only press Softkey 4 labeled EXIT to return to the main Interrogator menu which is shown below:



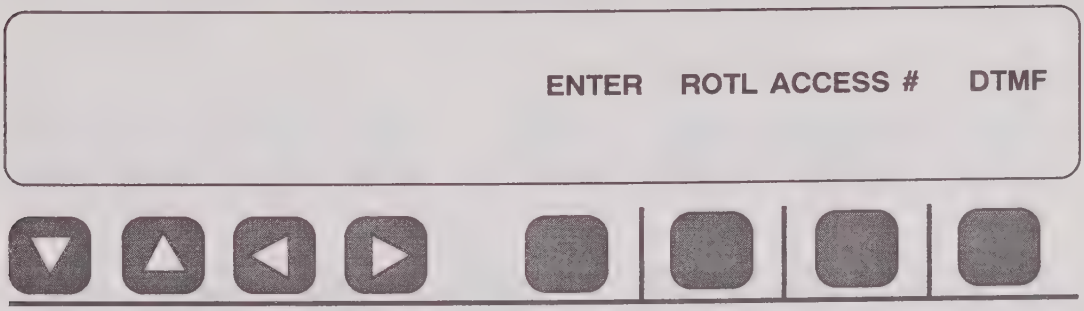
4-7.3.4 TESTING WITH THE INTERROGATOR FUNCTION

The main Interrogator display is shown below for discussion purposes.

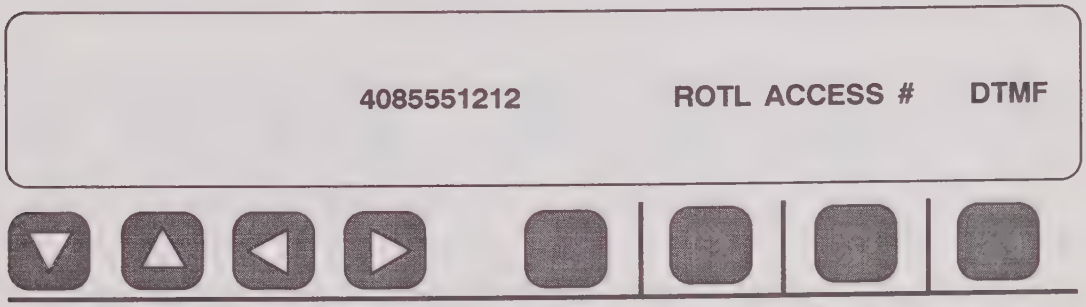


To begin testing using the Interrogator function, the operator should press Softkey 2 labeled TEST. The 930A display will then change to one of two possible displays.

If no ROTL Access number has previously been entered, the 930A will prompt the user to enter one as shown below:



The digit sequence may be DTMF, MF or Dial Pulse. The operator may select the appropriate form by pressing Softkey 4 until the correct type is displayed. The operator then enters the ROTL Access number as an MF, DTMF or DP sequence. If a sequence had previously been entered, it would have been displayed instead as shown below:



Of course, this could just as well have been a DP or an MF sequence. The above is for example purposes only. If another number is desired simply press the CLR key and enter the desired number.

Another possibility is that the 930A is connected directly to the ROTL access port of a switch and therefore no number is required. Simply press the CLR key to remove any existing numbers and then just go OFF HOOK.

When the 930A is connected to a dial-up line or at the DSX and the correct number has been entered, the operator need only place the front panel hook switch in the OFF HOOK position.

In either case, the operator will get an audible indication of call completion or an audible indication that the call has not completed (Busy Signal, etc.). The 930A automatically advances to the ROTL priming screen

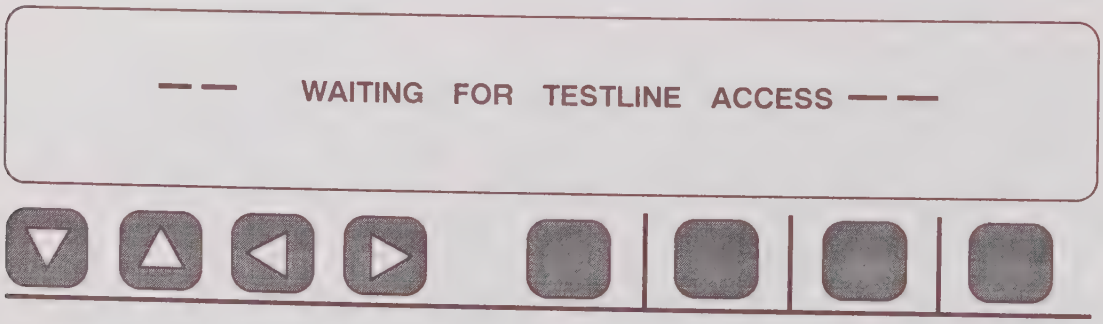
when the operator goes OFF HOOK. The operator must wait until the audible indication of call completion before sending the ROTL priming digits. An example of the ROTL priming screen is shown below:

The ROTL priming digits are repeated from the set-up display and offer the user another chance to edit them or enter a new string without having to go back through the set-up procedure. The flashing cursor over SEND prompts the operator to press Softkey 4 to outpulse the ROTL priming digits after the ROTL access has been obtained.

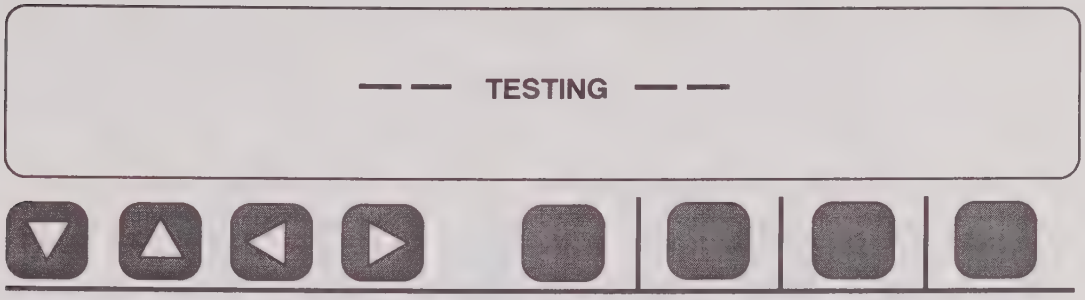
If the 930A is operating under remote control, the priming digits will be outpulsed automatically when the ROTL is accessed.

The operator can stop the testing (if, for example, the ROTL is busy) by going On-Hook.

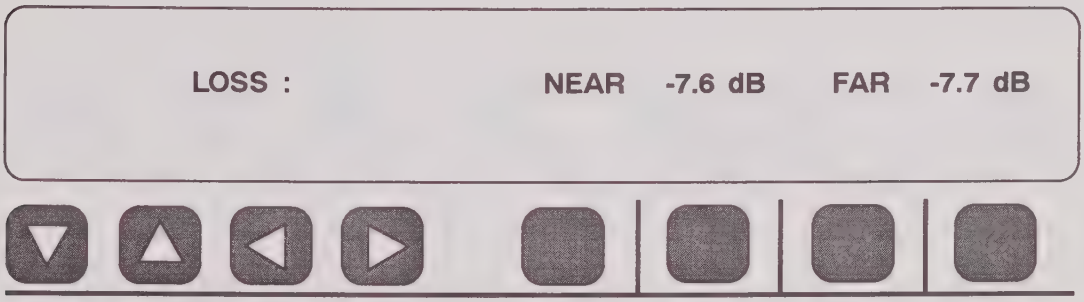
After Softkey 4 (SEND) has been pressed the 930A display will change to the following:

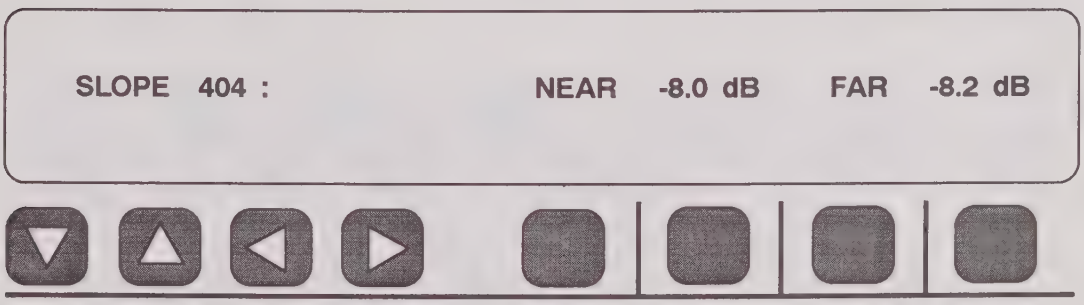


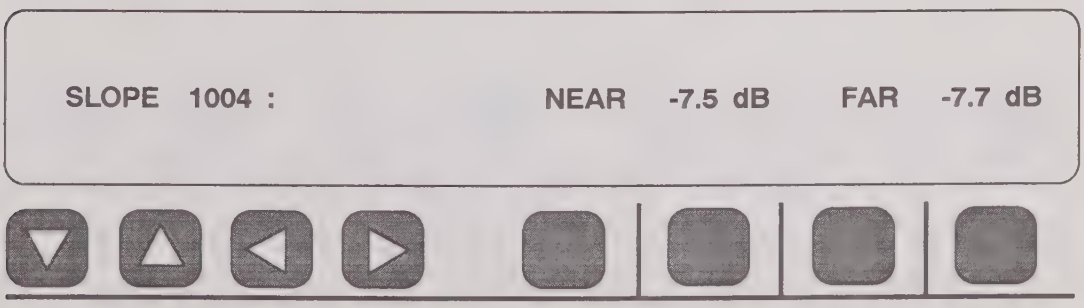
At this point the 930A waits to receive the test progress tones before continuing. These will be audible and once they have been received the 930A will automatically proceed with testing and the display will momentarily appear as shown on the following page:

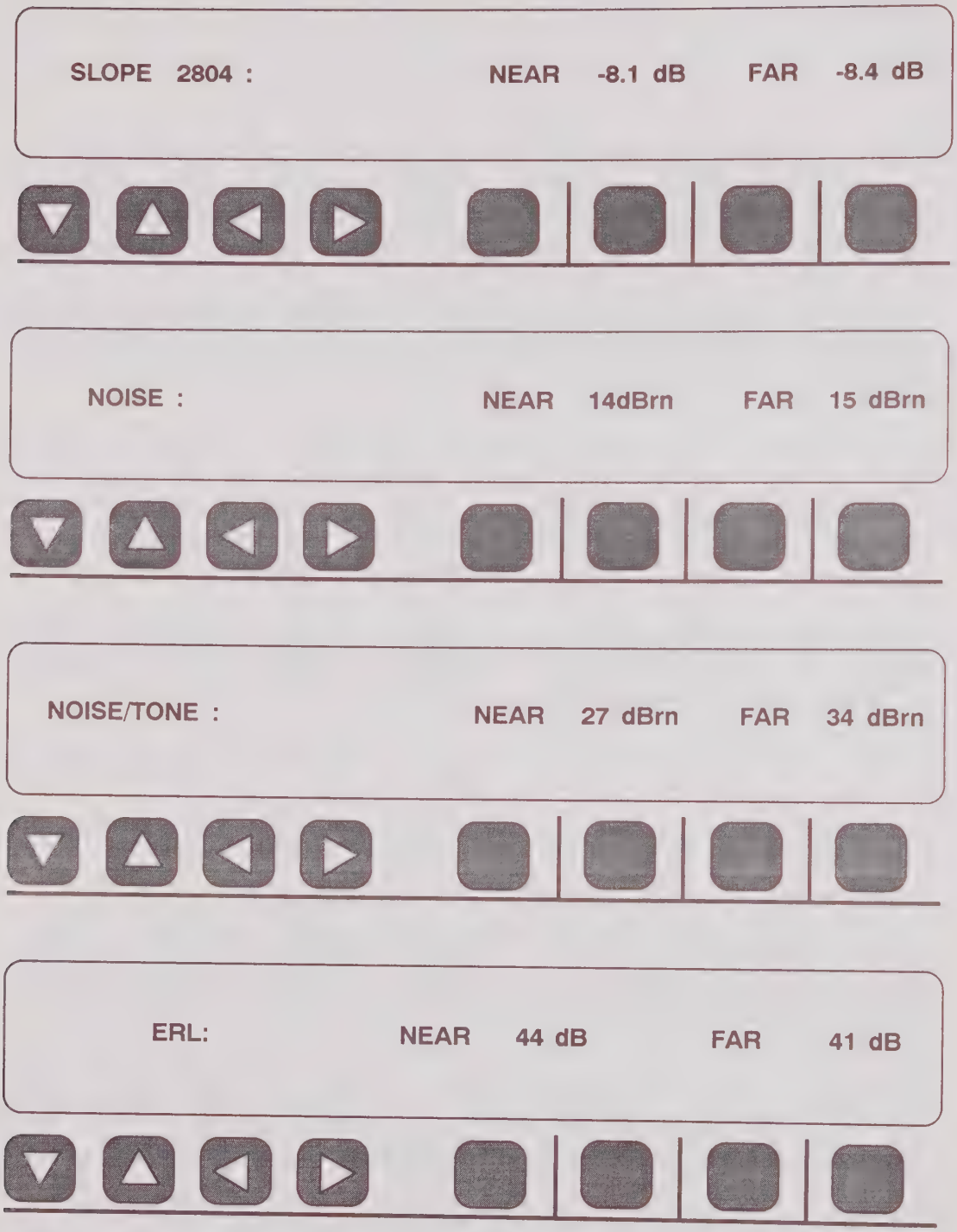


The tests are audible and test results will begin to show on the display just as the ROTL/Responder test results in Section 4-7.2 were displayed. A typical series of test results is shown below for example purposes:



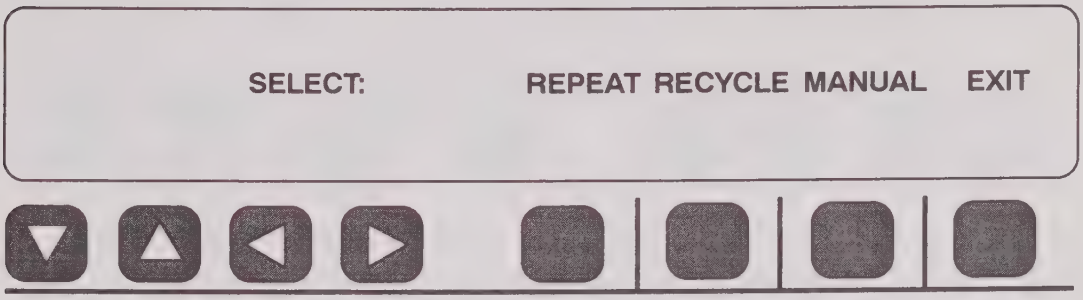






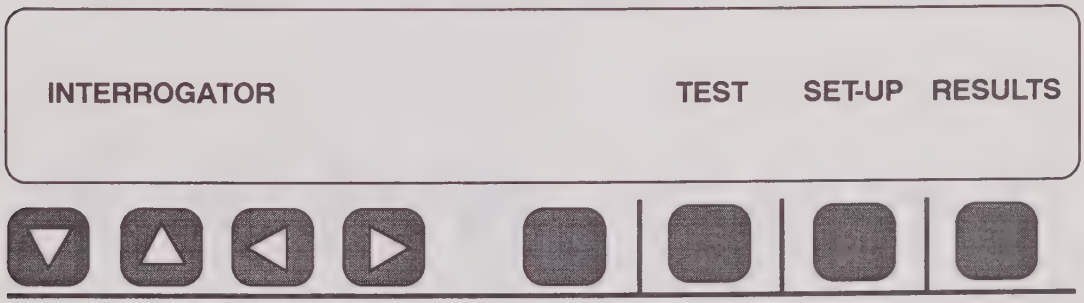
The 930A sequences through the selected tests at a fairly rapid rate and flashes the results of each test briefly to indicate that it is still testing.

Once the sequence of tests has been completed, the 930A will automatically present the Selection display which is shown below:



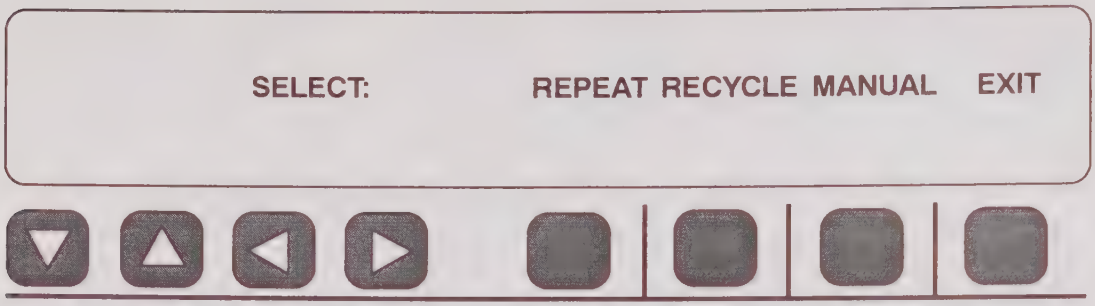
At this point, the 930A remains connected to the ROTL, the Trunk Under Test (TUT) and the Far-End Test Line (FETL), and testing can continue. The RECYCLE command will release the TUT and FETL, while holding the ROTL for further testing. To release the ROTL, go On-Hook.

If the operator simply wants to review the results of the previous test sequence, then pressing Softkey 4 (labeled EXIT) will bring back the main Interrogator display as shown below:



By pressing Softkey 4 (labeled RESULTS), the operator can scroll through the results of the last test sequence using the UP/DOWN arrow keys. This would be identical to the operation of the ROTL/Responder described in Section 4-7.2.

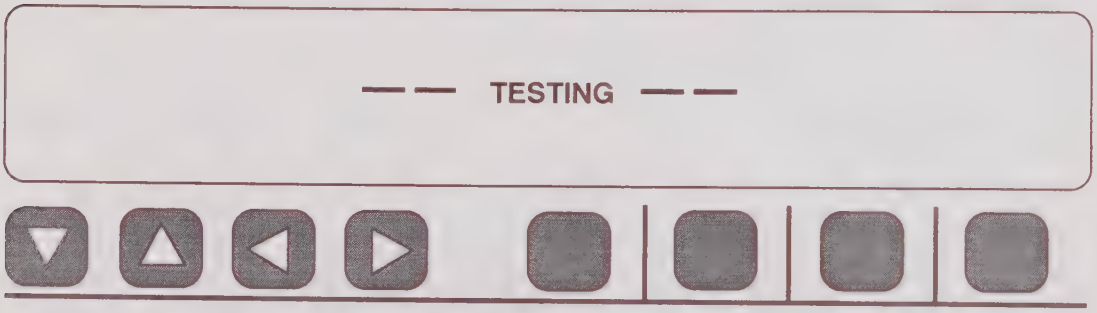
However, the Selection display enables the operator to do more than just review the results of previous tests. To discuss the other possibilities, the Selection display is repeated on the following page:



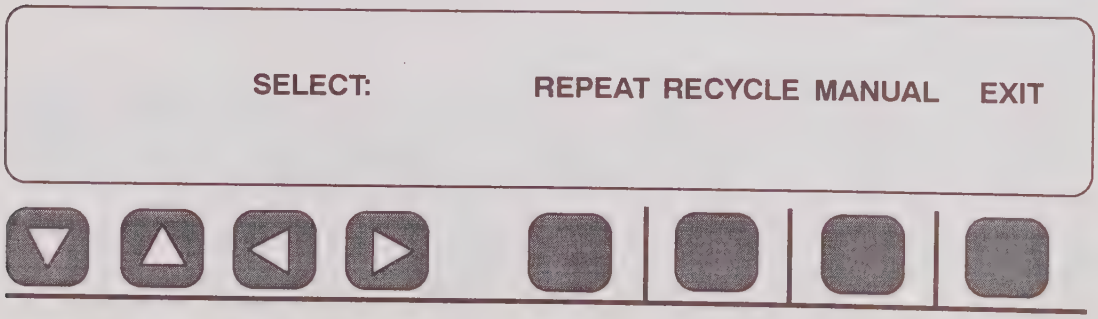
To begin, the four Softkeys are labeled REPEAT, RECYCLE, MANUAL and EXIT. The three functions will now be described.

The REPEAT function is accessed by pressing Softkey 1. The REPEAT function is straightforward and merely repeats or reruns the previously set-up test sequence. This enables the operator to quickly rerun a test without having to reenter all the set-ups. To illustrate the procedure, the sequence of events for using the REPEAT function is:

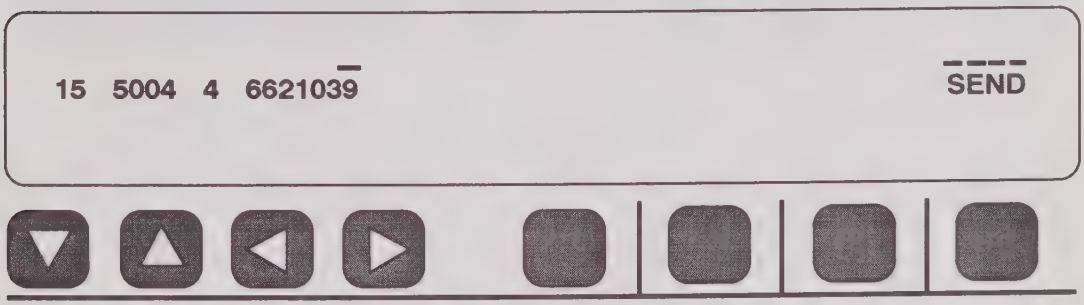
Press Softkey 1 (labeled REPEAT) in the SELECT display and the 930A will automatically rerun the previous test. The 930A display will revert to:



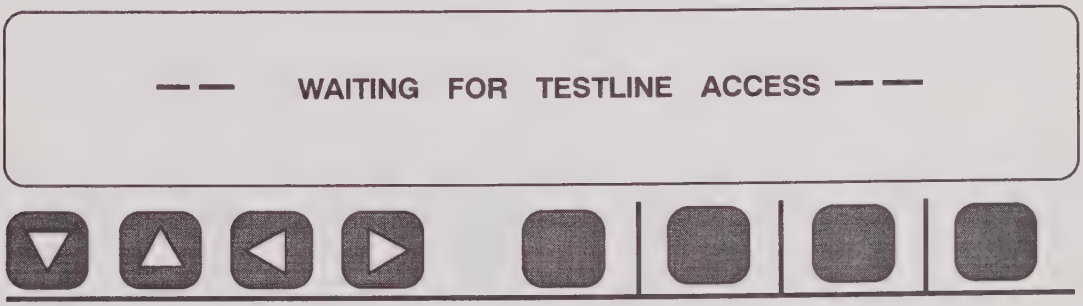
The tests will again be audible and the results will start to be displayed again as the test results are obtained. At the end of the test sequence the display will again revert to the SELECT display as shown below:



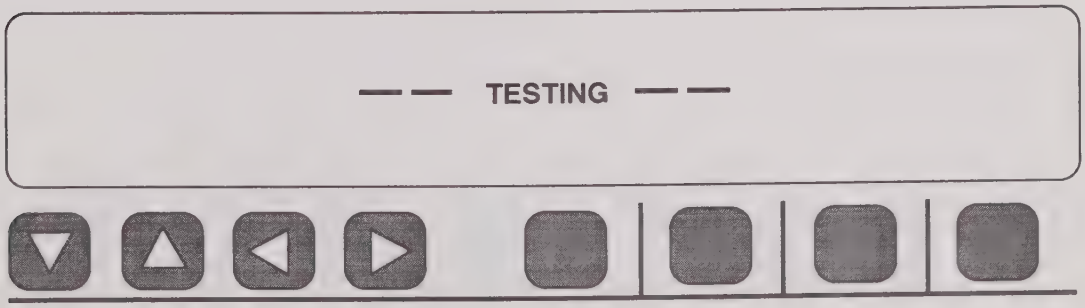
Suppose, however, that it is desired to change the ROTL priming digits. The RECYCLE function sends the 1300 Hz "recycle" command to the ROTL, then takes the 930A back to the priming digits screen. To illustrate this, assume that the RECYCLE Softkey has been pressed in the above display. The 930A will then send out the 1300 Hz "recycle" tone to the ROTL and will return the operator to the ROTL priming digit display as shown below:

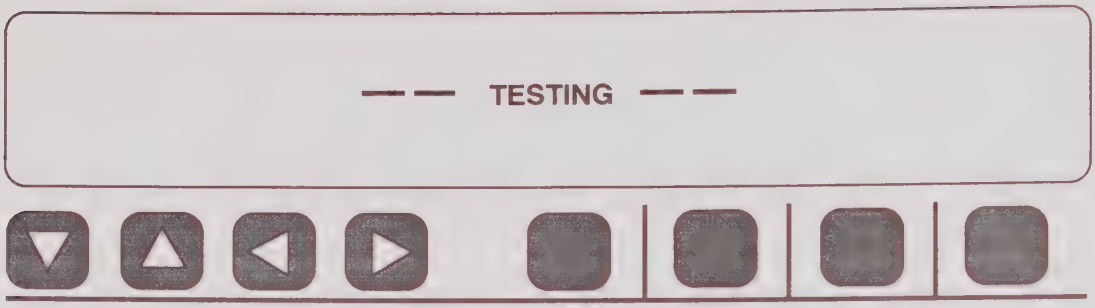


The operator can now edit the ROTL priming digits string easily and when that has been accomplished, the operator need only press Softkey 4 (labeled SEND) to outpulse the new ROTL priming digits. The 930A would then display the following:



The 930A waits to receive the three consecutive test progress tones and then starts testing. The next display will be:

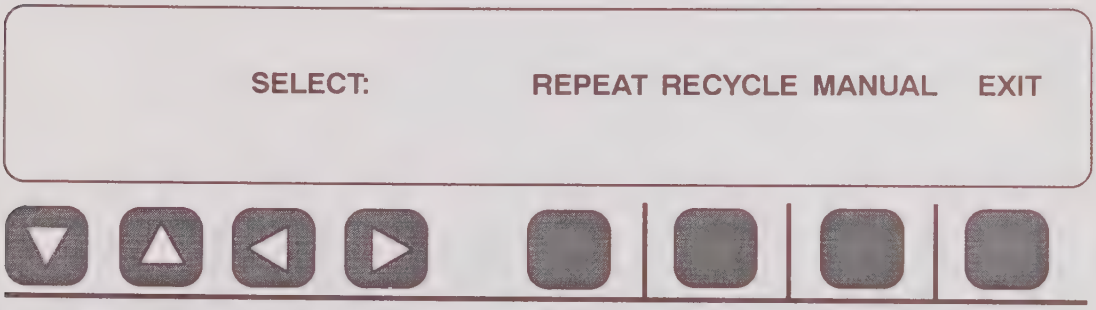




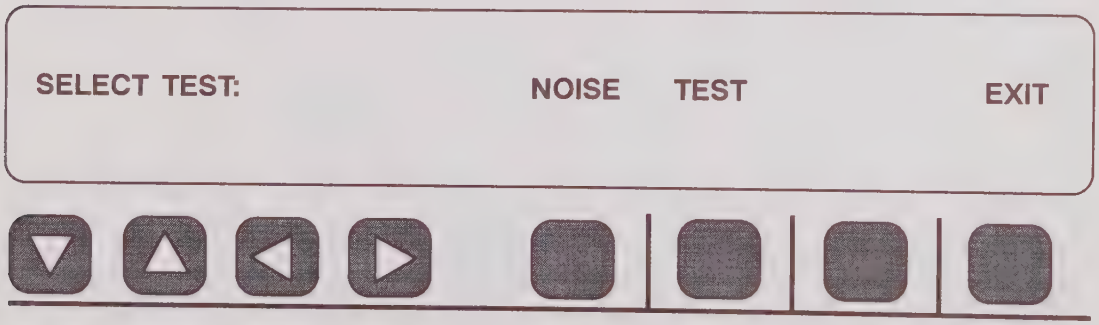
The 930A will start to receive and display the test results soon after the above display appears and the series of results will be displayed in much the same manner as the original test results although the actual results may be different.

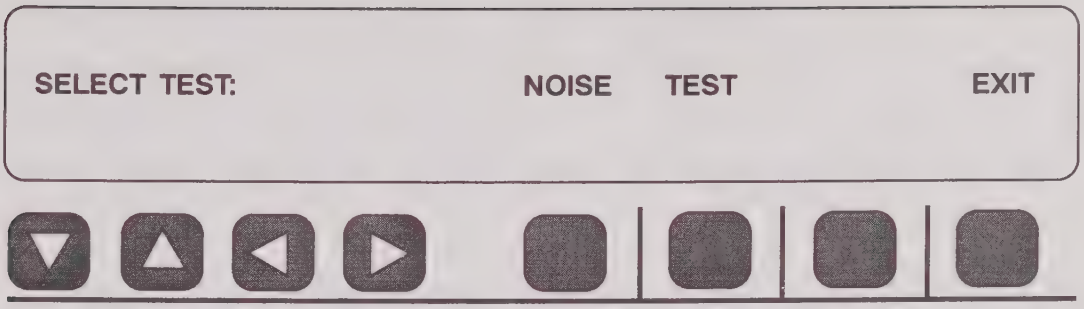
Finally, the operator may wish to repeat a single test or series of tests under manual control.

To illustrate the procedure for selectively repeating a single test we start at the SELECT screen which is repeated below for example purposes:



Press Softkey 3 (labeled MANUAL) and the 930A display will change to the following:





In the above example, the Noise test is displayed. The operator is free to choose any other test by simply pressing Softkey 1 until the desired test appears. The choices are LOSS, GAIN/SLOPE, NOISE, NOISE WITH TONE, ECHO RETURN LOSS, SINGING RETURN LOSS-LO, AND SINGING RETURN LOSS-HI. Once the desired test has been selected, the operator need only press Softkey 2 (labeled TEST) to begin testing. The operator could also have pressed Softkey 4 (labeled EXIT) to return to the SELECT display if the MANUAL mode was not desired.

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4-8 REMOTE AUDIO MONITOR (OPTION 930A-26)

Option 930A-26 (Remote Audio Monitor), when installed, provides the operator with remote access to the VF data on the trunk under test, via a separate dial-up line. This option enables troubleshooting "by ear" from a remote location.

Remote audio access is through a standard modular telephone jack (type RJ-11) located on the upper left of the 930A rear panel. The modular jack provides a loop appearance, and can be set to auto-answer or to dial out over any public switched telephone line. When the 930A is turned on, the remote audio line is placed On-Hook. The monitor can be set to automatically go Off-Hook when it detects ringing, or can be set to ignore incoming calls for security purposes.

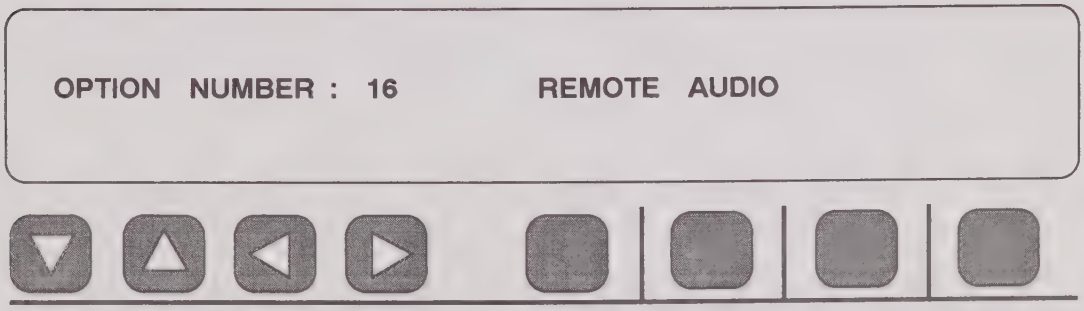
Commands to the remote audio line can be entered over the RS-232C Remote Control interface or manually through Menu Option Number 16: REMOTE AUDIO.

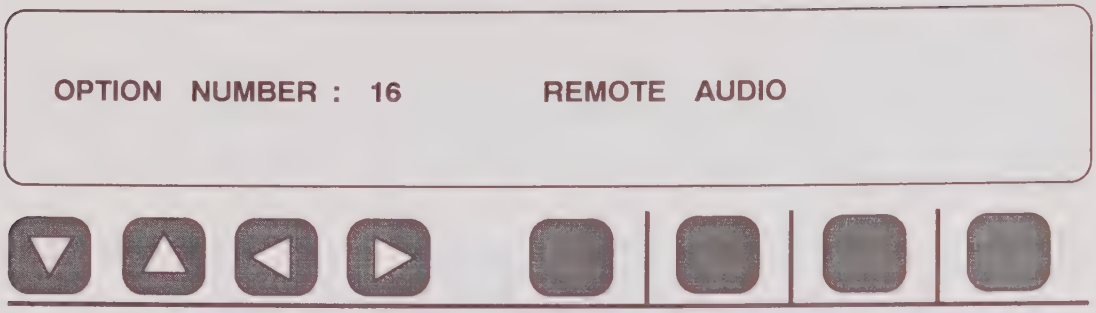
The following steps describe the set up and operation of the 930A with option 930A-26 installed. To begin:

Press the Option Menu **Option Menu** key.

Use the UP/DOWN arrow keys

to select Menu Option 16: REMOTE AUDIO. The 930A display will appear as:





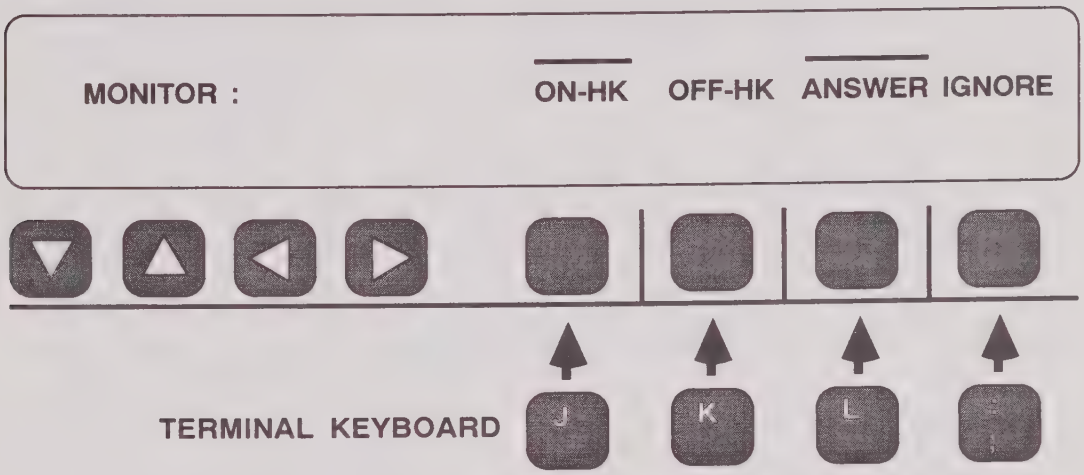
Pressing any Softkey will enter the function and the display will appear as shown below:

There will be flashing cursors to indicate whether the audio monitor is currently ON or OFF-HOOK, and whether it has been programmed to answer or ignore incoming calls. In the above example, the remote audio line is On-Hook and ready to answer incoming calls.

If the remote line has been set to answer incoming calls, it will respond to ringing by going Off-Hook.

When the remote line is Off-Hook, the sounds normally heard over the 930A's speaker are instead transmitted over the remote line, and are audible to the operator at the remote location.

The previous display is repeated below to facilitate the description of the operation of this option. The Softkeys or the Keyboard of a Terminal or Computer connected to the 930A via the RS-232 interface may be used to control the audio monitor option.



Press Softkey 1 (Remote Control "J") to place the remote line On-Hook.

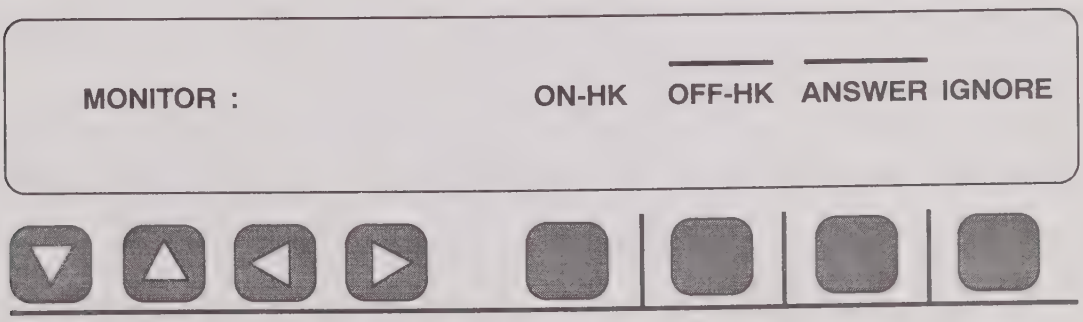
Press Softkey 2 (Remote Control "K") to place the remote line Off-Hook.

Press Softkey 3 (Remote Control "L") to answer incoming calls.

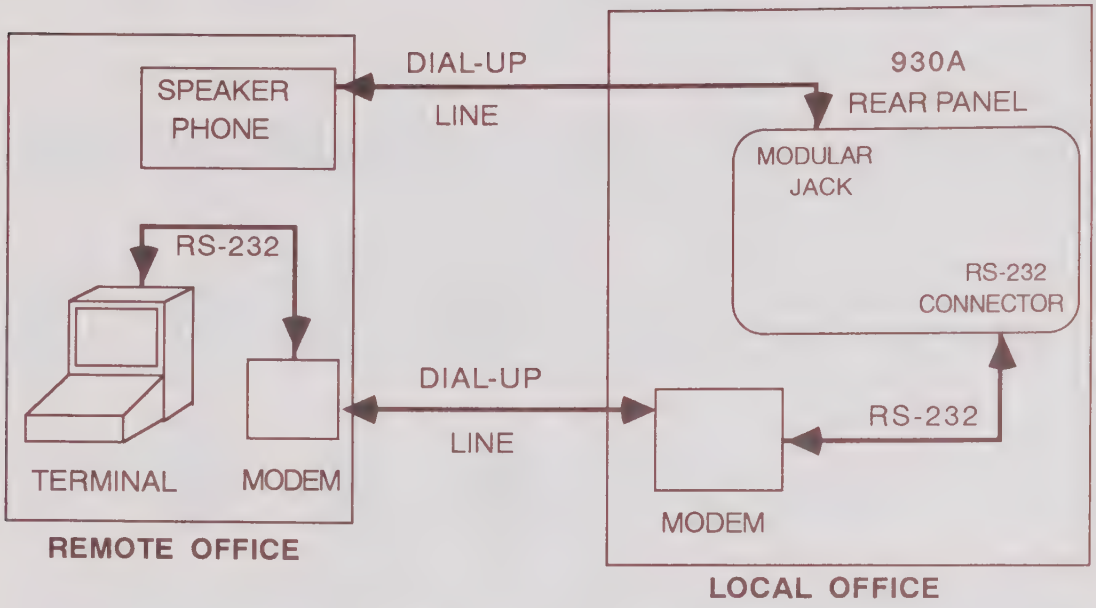
Press Softkey 4 (Remote Control ";") to ignore incoming calls.

Press the Option Menu key (Remote Control "G") to exit.

If Softkey 2 had been pressed or an uppercase ASCII "K" had been sent over the RS-232 interface in this example, the 930A display would change to:



The connection of the 930A for remote audio operation is diagrammed below:



REMOTE AUDIO CONNECTION
FIGURE 4-17

To dial out on the remote audio line, place the 930A in a monitor mode (BRIDGE on analog circuits, THRU on PCM), so that its output will not affect the trunk under test. Take the remote audio line Off-Hook, either by sending the remote command "M" or manually through Menu Option 16 as previously described. Press the Dial/Ring function key or send the remote command "B" and select DTMF outpulsing (Refer to Section 3-7). Outpulse the telephone number of the remote operator's speaker phone. When the connection has been established, the operator may then put the 930A back into an active (non-monitor) testing mode.

When a remote audio connection has been established, the remote operator may converse over the trunk under test, just as if he were using the headset jacks on the 930A front panel. The remote operator may also converse with the local operator through the 930A by placing the 930A in Dial/Ring mode and having the local operator plug into the headset jacks.

When testing has been completed, return to Menu Option 16 and place the 930A back to the On-Hook condition.

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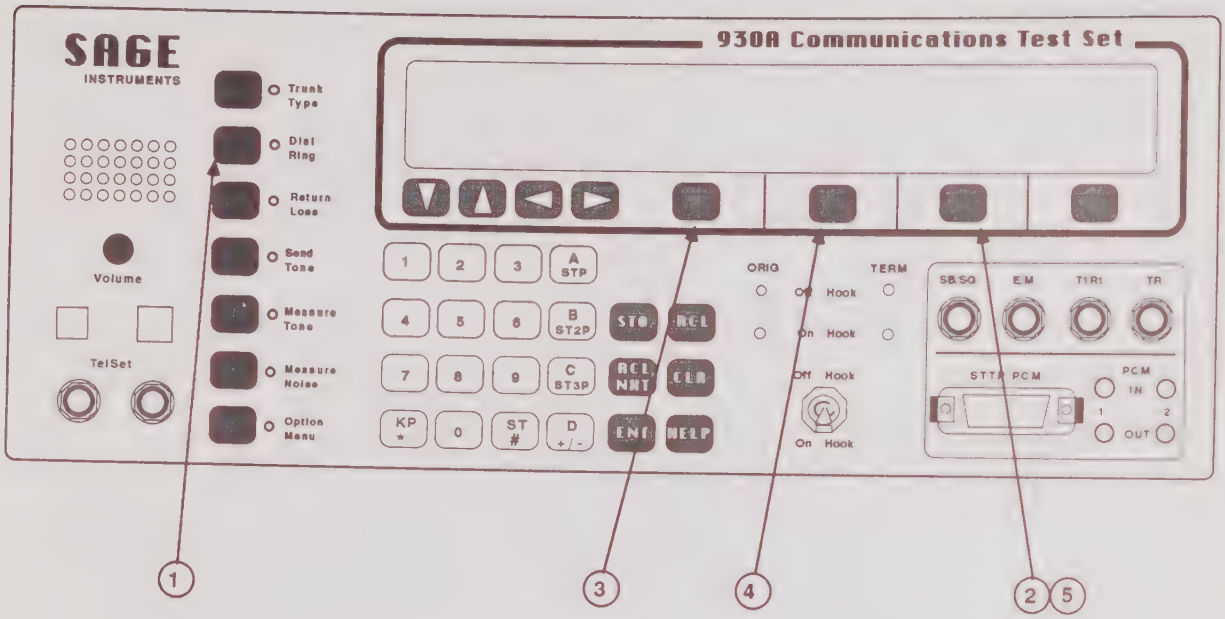


To select the RING mode of operation:

1. Press the DIAL/RING Function key.
2. Press Softkey 3 until the display indicates RING.
3. Press Softkey 1 (labeled MANUAL) to cause Ringing.
4. Press Softkey 2 (labeled RPT?) to cause intermittent Ringing.
5. Press Softkey 3 to reenter the DIAL mode.

CAUTION

THE RING GENERATOR CAN PRODUCE
POTENTIALLY DANGEROUS VOLTAGE LEVELS.
DO NOT TOUCH TEST LEADS WHILE GENERATOR IS OPERATING.

RING GENERATOR OPERATION
FIGURE 4-18

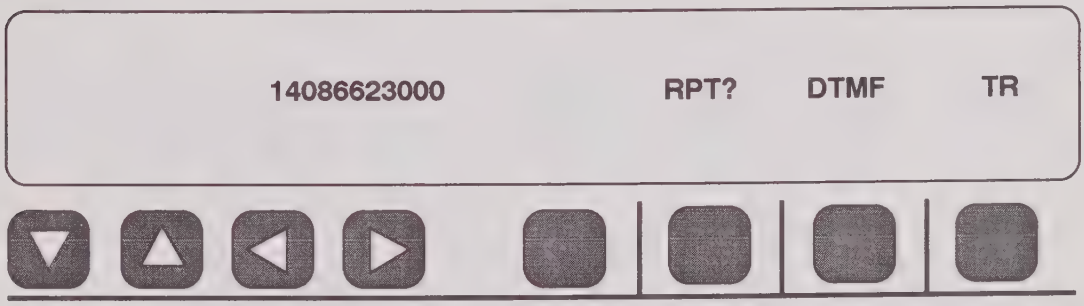
4-9 RING GENERATOR/REN-3 LOAD (OPTION 930A-13)

The 930A may be equipped with a Ring Generator and Ringer Equivalent Number 3 Load by installing Option 930A-13. This option provides a nominal sinewave ringing voltage of 87 Volts RMS. The ringing voltage level, ringing frequency and ON/OFF times are adjustable. A true Ringer Equivalent Number 3 (REN-3) load is also provided to terminate ringing supplies. The Ring Generator is intended for operation on 2 and 4-wire Loop Start, Ground Start, and Reverse Battery trunks. Prior to using the Ring Generator, the correct trunk type must be selected as described in Section 3-6.

The following steps outline the set-up and operation of the Ring Generator. To begin:

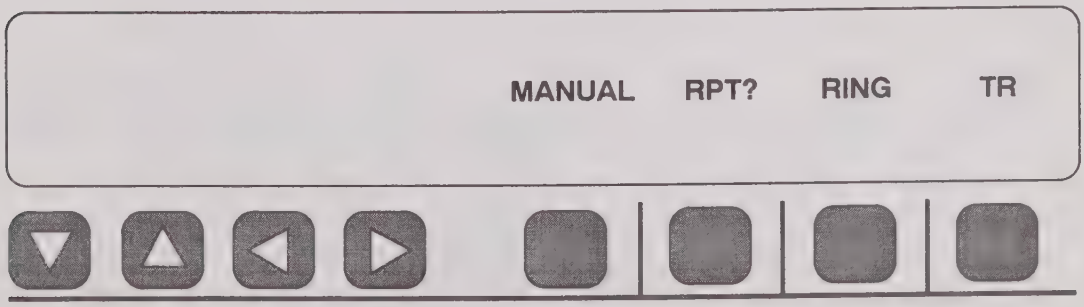
Press the DIAL/RING **Dial/ Ring** function key.

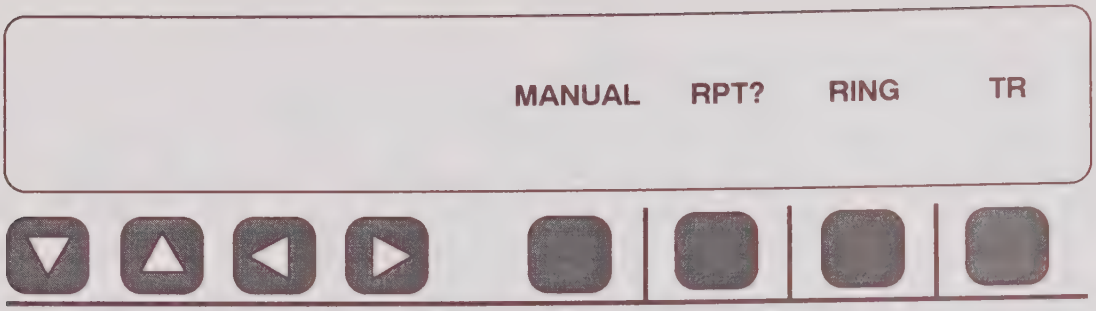
An example of a typical 930A display in DIAL/RING mode is shown below:



The 930A "remembers" the last settings and in this example, the last thing done in Dial/Ring was to send the DTMF sequence shown. To select the Ring Generator, perform the following steps:

Press Softkey 3 (labeled DTMF in the above display) until the following display appears.





Once in the RING mode of operation shown above, the front panel key operation is as follows:

Press Softkey 1 (labeled MANUAL) to cause Ringing to appear at the TR jack. The ringing voltage will remain on as long as Softkey 1 is pressed.

Press Softkey 2 to cause an intermittent ring continuously at the TR jack.

Pressing Softkey 3 will reenter the DIAL mode of operation.

Softkey 4 is inactive.

4-9.1 MODIFYING RING GENERATOR LEVEL/FREQUENCY

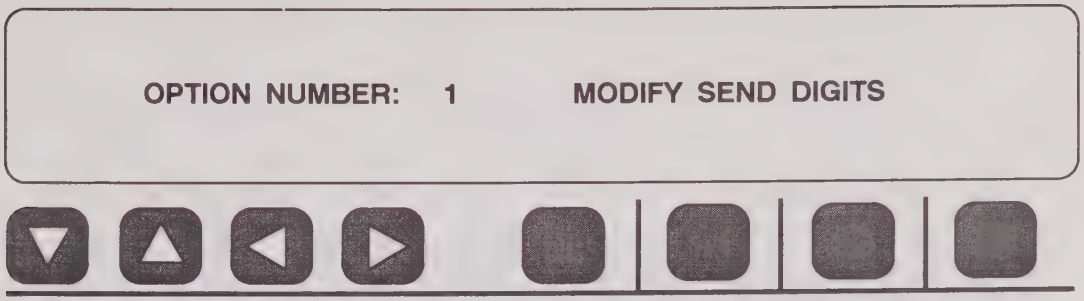
The Amplitude and Frequency of the Ring Generator can be modified in a manner similar to the way in which outpulsed digit parameters are modified (Section 3-12.1).

Menu Option 1: MODIFY SEND DIGITS, is used to modify the amplitude, frequency and timing of the Ring Generator. To begin testing, after selecting the RING mode of operation, perform the following steps:

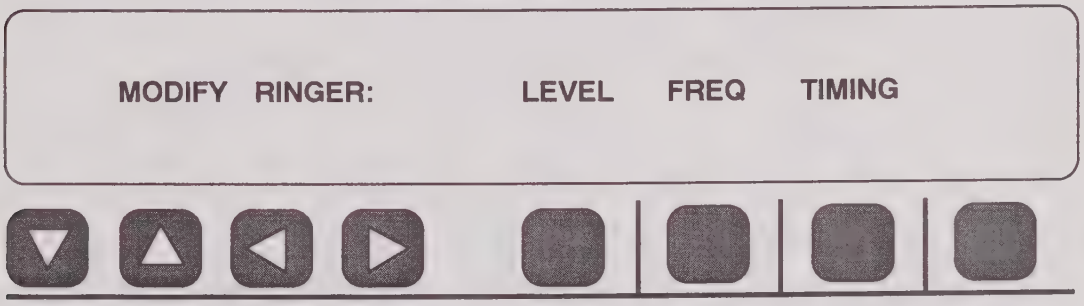
Press the OPTION MENU **Option Menu** function key.

Use the UP/DOWN arrow keys to select Menu Option 1: MODIFY SEND DIGITS.

The Model 930A display will appear as follows:

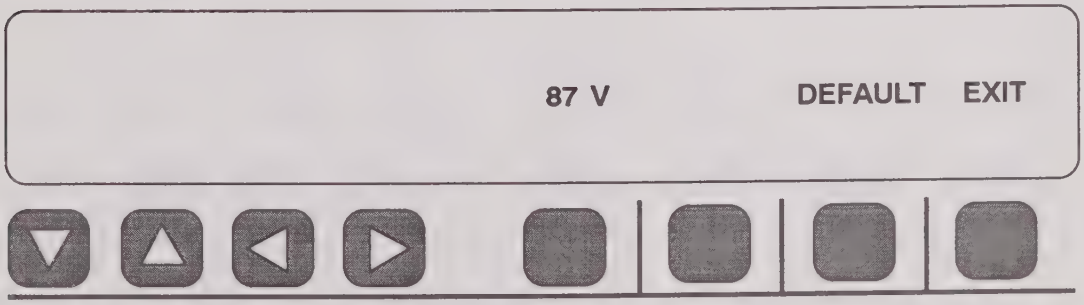


Press any Softkey to enter the menu option and the 930A display will become:



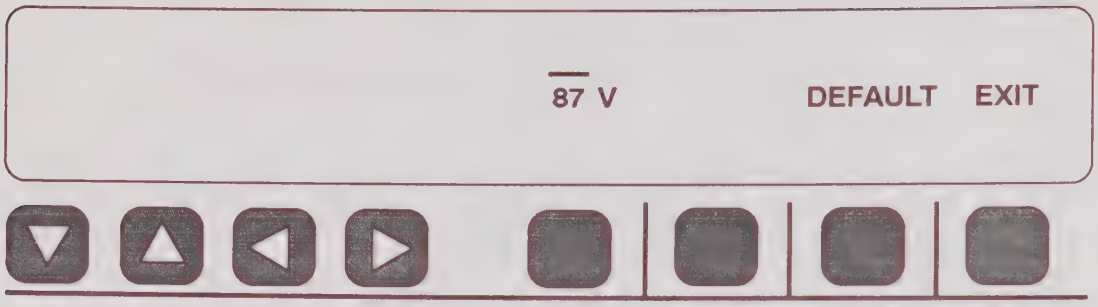
Press Softkey 1 to inspect or modify Ringer level.
Press Softkey 2 to inspect or modify Ringer frequency.
Press Softkey 3 to inspect or modify Ringer On/Off time.
Press the OPTION MENU function key to exit the menu.

Pressing Softkey 1 (LEVEL) will bring up the following display:

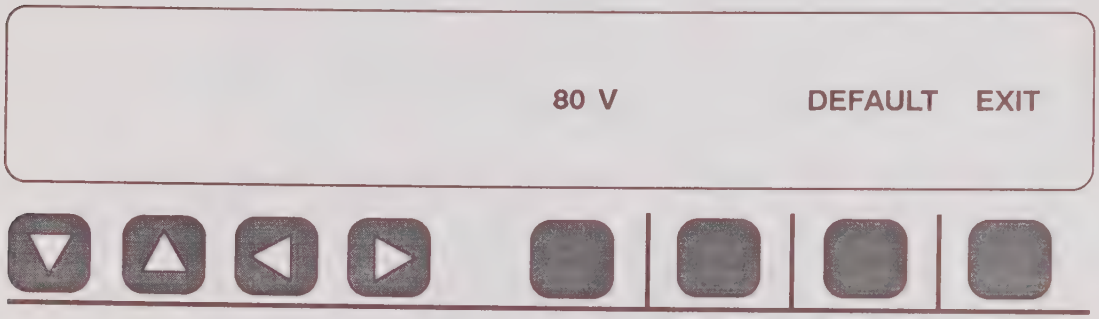


The operator may now enter the desired voltage using the numeric keypad. For example, suppose that a value of 80 Volts RMS is desired. Press Softkey 1 and a cursor will appear over the present value as shown on the following page.

The 930A display will now appear as:

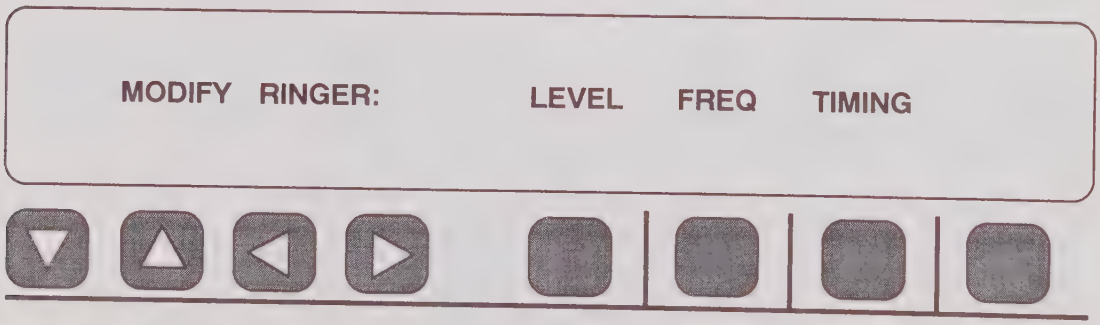


Use the numeric keypad to enter the desired value (80) and then press the ENTER key and the 930A display will become:

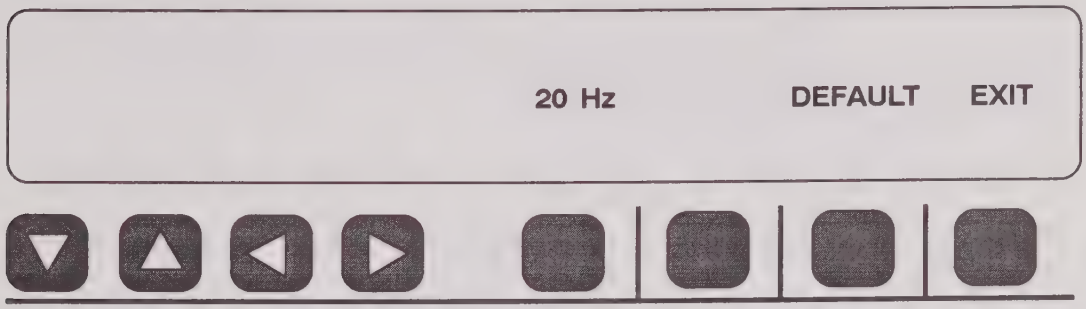


Pressing Softkey 4 at this point would exit back to the Option Menu. Pressing the DIAL/RING function key would return the 930A to the Ring mode and the ringing voltage output from the TR (or T1R1) jack would now be 80 Volts RMS whenever the RING function was used. Note the ">" marker which precedes the RING mode identifier to alert the operator that a parameter (LEVEL in this case) has been modified.

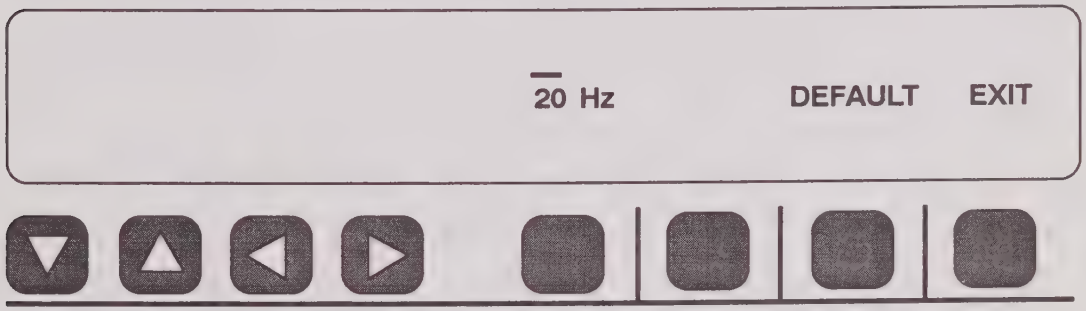
Similarly, the operator may change the Ring frequency from the default value of 20 Hz to some other value. For example, suppose that it is desired to change the Ring frequency to 30 Hz. The option screen is repeated below:



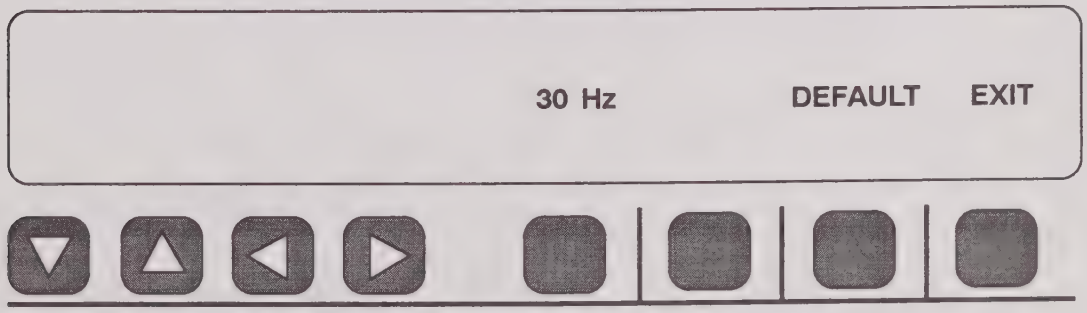
To change frequency press Softkey 2 (labeled FREQ) and the display appears:



Press Softkey 1 and a cursor appears over the 20 Hz display indicating that the value can now be changed. The display is as follows:



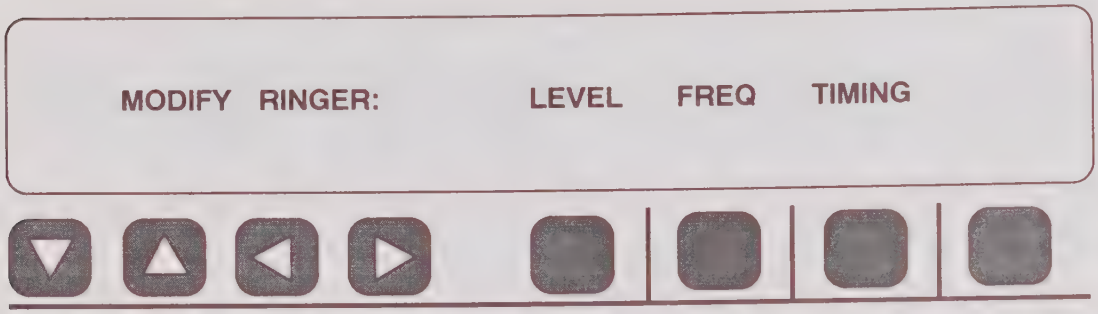
Enter the desired value using the numeric keypad (3 and 0 in this example) and then press the ENTER key to initiate the new value and the 930A display will change to:



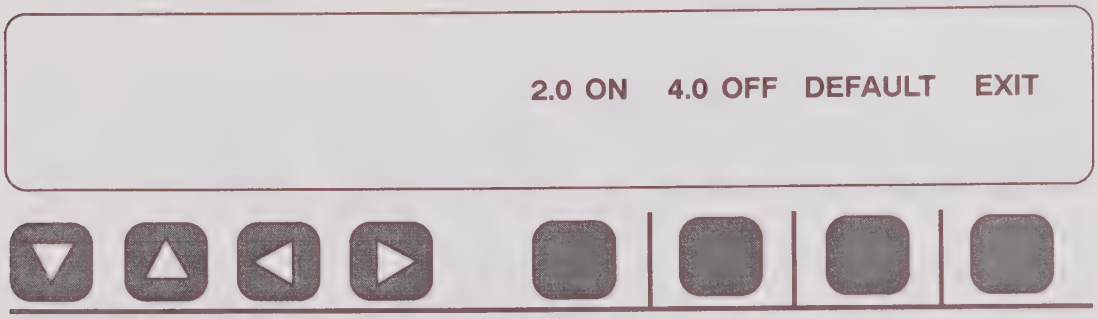
The next step is to press either Softkey 4 to Exit back to the Option Menu or to press the DIAL/RING function key to go directly to the RING mode. Once in the RING mode, the Ringing frequency will now be 30 Hz whenever the Manual or RPT? Softkeys are pressed.

To return to the factory default values, press Softkey 3 (labeled DEFAULT).

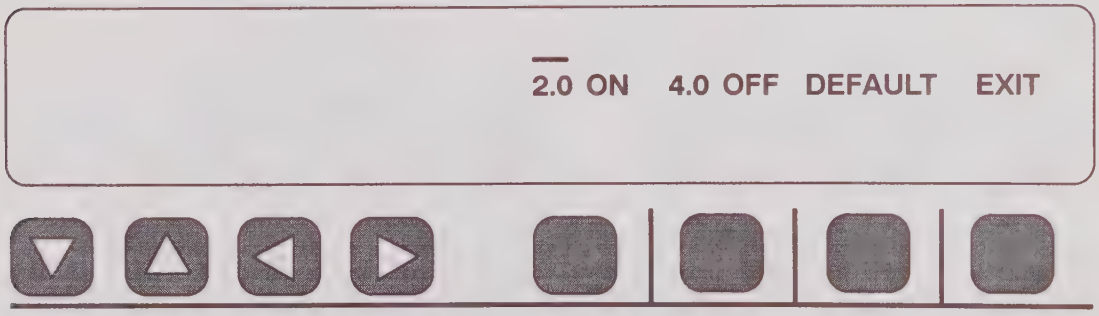
To modify the ON/OFF Ringer interval timing, it is necessary to return to the selection menu by pressing Softkey 4 or the OPTION MENU function key. The selection display is repeated below:



Press Softkey 3 (labeled TIMING) and the 930A display will change to:

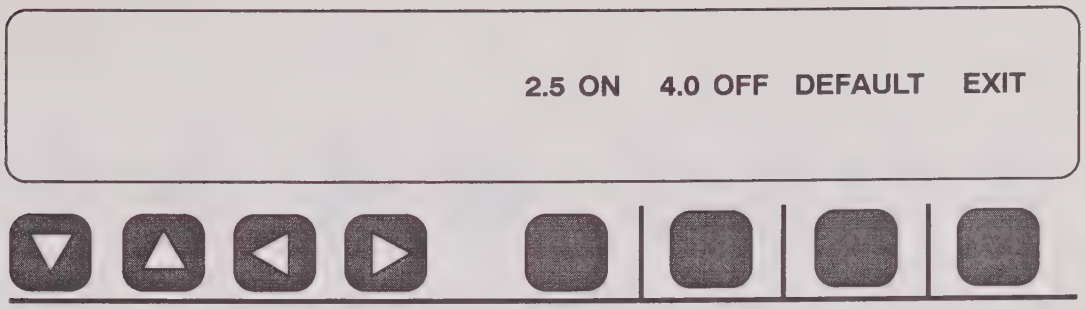


In this case, a 2 second On and 4 second Off time interval (the default values) is displayed. To change, for example, the On time to another value press Softkey 1 and a cursor will appear over the present ON time value as shown below:



To change the ON time to 2.5 seconds for example, use the numeric keypad to enter 2 and then 5 and press the ENTER key. The 930A display will change

to the following:



Press Softkey 4 to exit back to the selection menu or press the DIAL/RING function key to exit back to the RING mode.

To return to the factory default values, press Softkey 3 (labeled DEFAULT) and the factory settings will be restored.

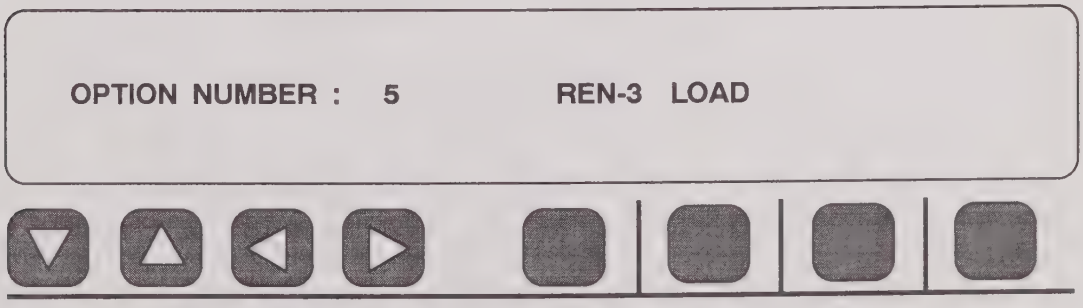
4-9.2 RINGER EQUIVALENT NUMBER 3 (REN-3) LOAD

To cause the 930A to act as a REN-3 load perform the following steps:

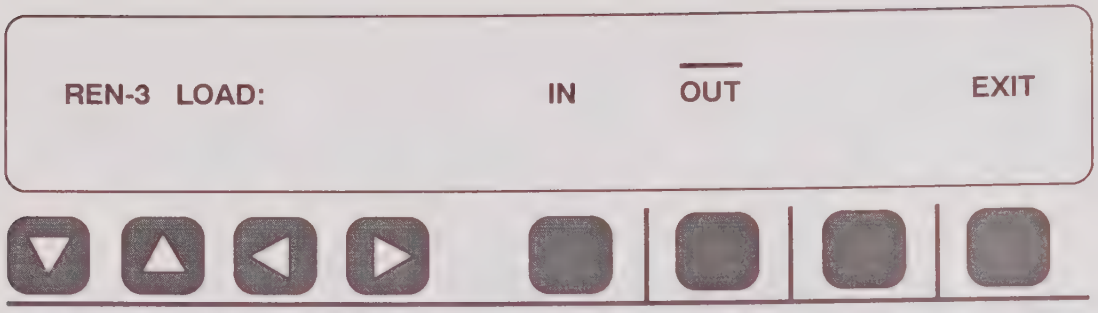
Press the OPTION MENU Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 5: REN-3 LOAD.

The Model 930A display will appear as:

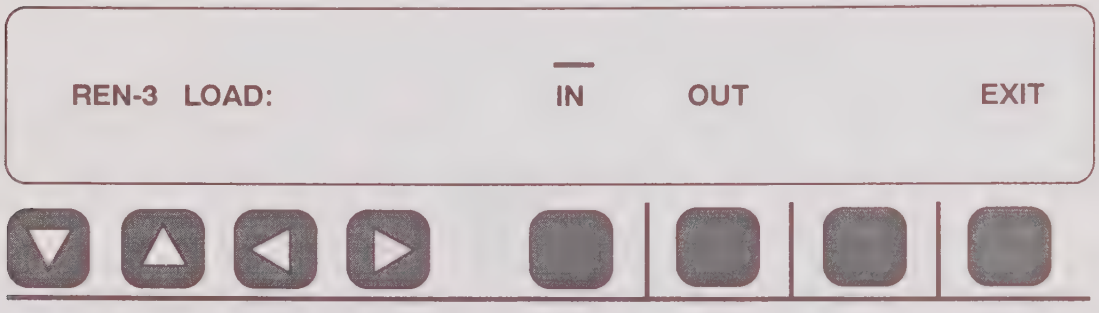


Enter the menu option by pressing any Softkey and the display will become:



In this example the REN-3 Load was previously out as shown by the cursor above OUT. If the operator desires to have the 930A act as a true REN-3 Load at its TR or T1R1 jacks, then Softkey 1 (labeled IN above) must be pressed.

The Model 930A display will change to the following:



Once "IN" has been selected, the operator can press Softkey 4 to Exit back to the Option Menu or simply stay in menu option 6 if it is desired to merely present a REN-3 Load. The default condition of this menu option takes the load off line or "OUT".

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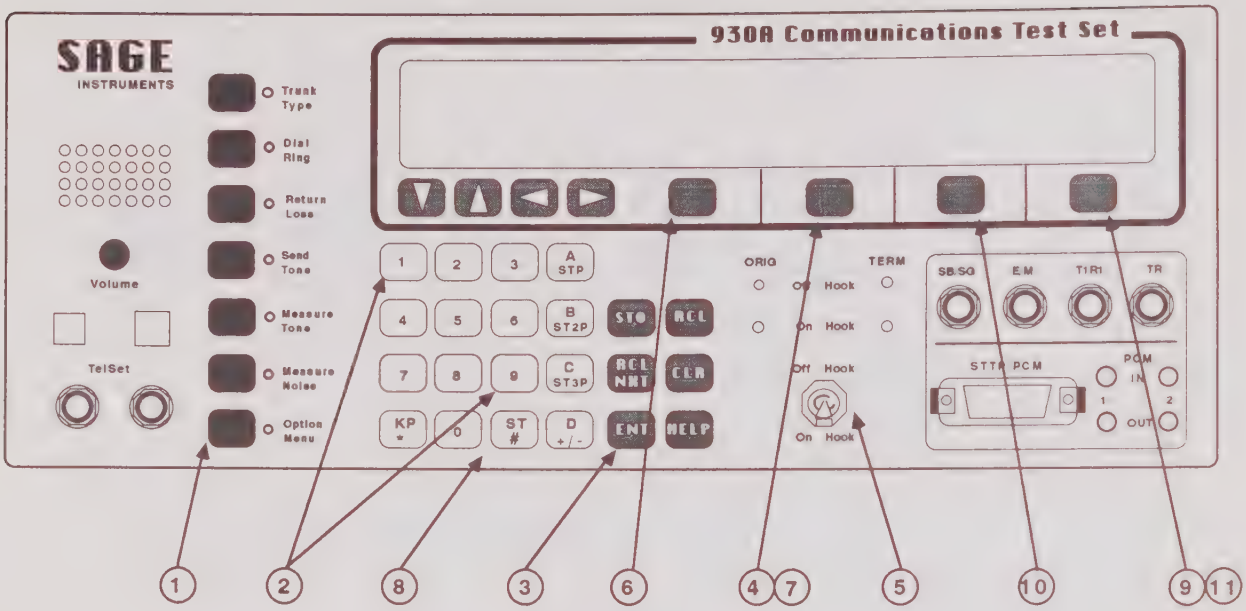


To select the 4-Tone Intermodulation Distortion measurement:

1. Press the OPTION MENU Function key.
2. Use the numeric keypad to enter the number 19.
3. Press the ENT (Enter) key to complete the numeric entry.
4. Press Softkey 2 (labeled SEND) to adjust the transmit level, to select Signal to Noise test tones, or send the 4 tones over a 2-wire circuit.
5. Ensure that the 930A is OFF HOOK before trying to send test tones.
6. Press Softkey 1 to select Signal to Noise.
7. Press Softkey 2 to send the 4-tones.
8. Use the numeric keypad to enter new send levels.
9. Press Softkey 4 to Exit back to the main IMD menu.
10. Press Softkey 3 (labeled MEASURE) to measure signals on the line (This does not disable tones being sent under the SEND sub-menu in step 4 above).
11. Press Softkey 4 to Exit the menu and stop the test.

4-TONE INTERMODULATION DISTORTION
FIGURE 4-19

4-10 INTERMODULATION DISTORTION (OPTION 930A-20)

Option 930A-20, when installed in the 930A provides an Intermodulation Distortion (IMD) measurement capability. Intermodulation Distortion measures the second and third order distortion products created in a non-linear circuit in the presence of a four tone signal.* This signal consists of two pair of tones (857 Hz, 863 Hz and 1372 Hz, 1388 Hz). The second order distortion products occur around 520 Hz and 2240 Hz while the third order products occur around 1900 Hz. These measurements are expressed in terms of dB below the received value of the desired signal. The frequency ranges of the second and third order terms show that if the distortion products have sufficient amplitude in these bands they can cause errors in Modem data transmissions. IMD is not usually a problem on voice-only circuits since it would be discernible only as an increase in background noise. However on data transmissions over voiceband facilities, IMD can be a serious impairment.

Intermodulation Distortion, sometimes referred to as Non-Linear Distortion or 4-Tone Intermod, is an end-to-end measurement. That is, one test set sends the tone pairs at 857 Hz, 863 Hz and 1372 Hz, 1388 Hz while the other set has it's receiver looking at a band of frequencies centered around 520 Hz, 2240 Hz and 1900 Hz. The energy received in these filters constitutes the energy in the second and third order IMD products. On 4-wire circuits, a loopback can be inserted at the distant end so that one set may send and receive. On a 2-wire circuit two sets are required, with one set either sending or receiving in turn.

Before testing, the user must select the appropriate Trunk Type (Refer to Section 3-6) and connect the 930A to the circuit. Once this has been accomplished, perform the following steps to place the 930A in the Intermodulation Distortion measurement mode:

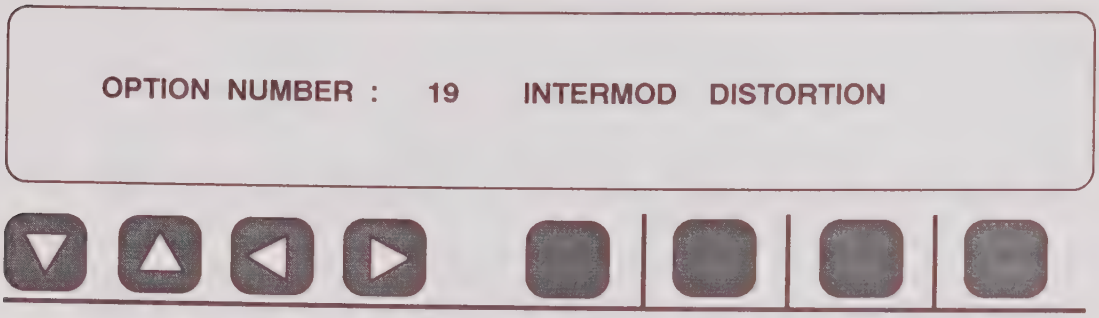
Press the Option Menu **Option Menu** key.

Use the UP/DOWN arrow keys

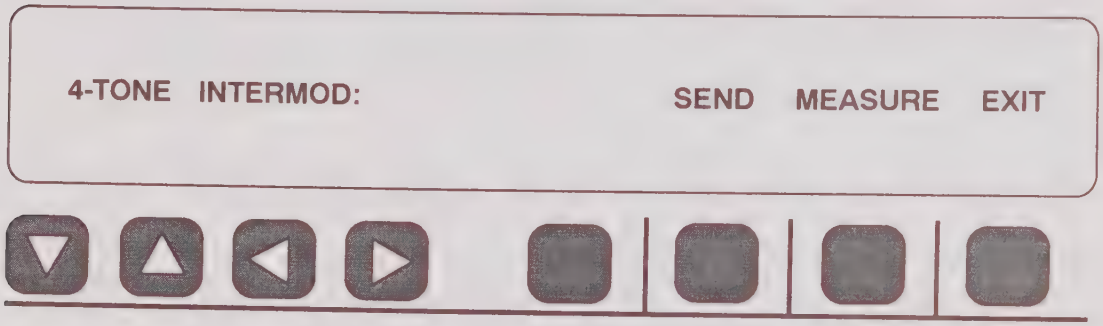
to select Menu Option 19: INTERMOD DISTORTION.

* Licensed under HLI Patent No. 3,862,380

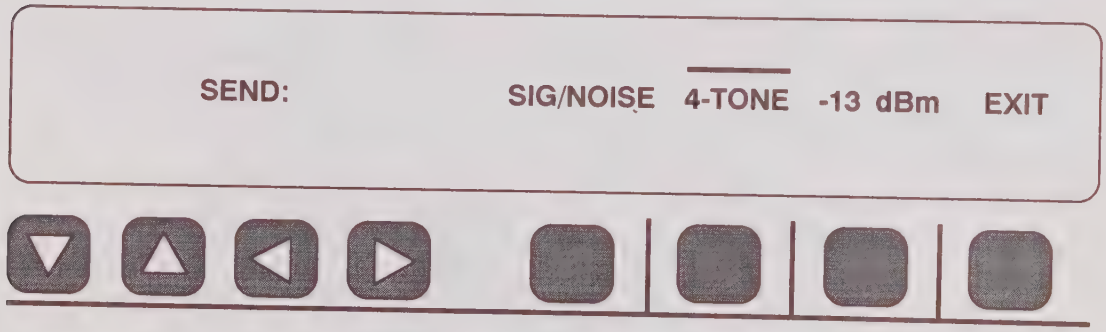
The Model 930A display will appear as shown below:



Press any Softkey to enter the menu option and the display will become:

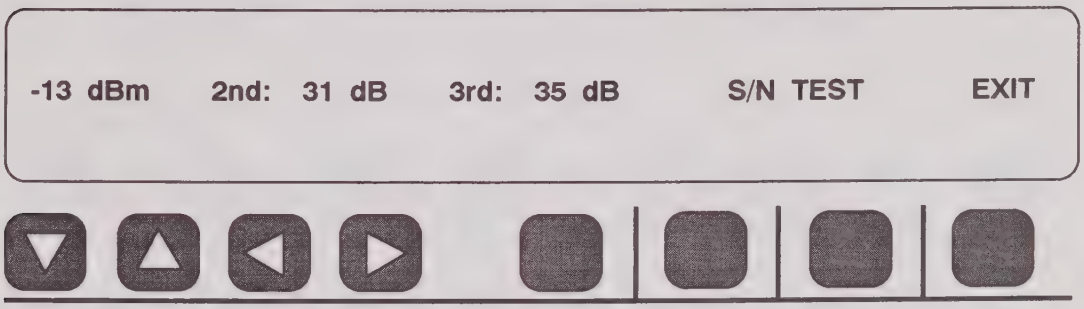


Press Softkey 2 (labeled SEND) to adjust the level at which the IMD tones are sent, to select the signal-to-noise test tones, or simply to send the Intermod tones over a two-wire circuit. Pressing Softkey 2 will bring up the following display:

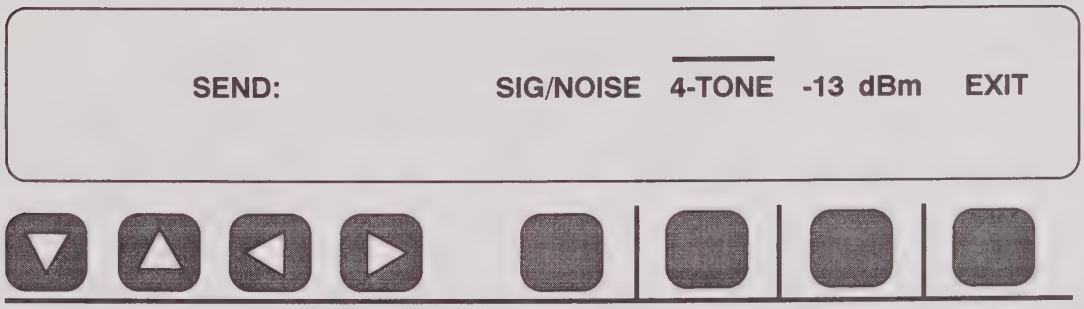


The cursor appears over the last test selected. To send the signal-to-noise test tones, press Softkey 1 (labeled SIG/NOISE). This will suppress one tone pair while amplifying the other pair to maintain the same average level. This measurement is usually performed before IMD testing since the test set uses the S/N value to automatically correct the IMD measurement results.

A typical example of the Signal-to-Noise measurement display is shown below where the S/N values for the low and high tone pairs occupy the 2nd and 3rd order distortion positions:



Returning to the main SEND display:



Press Softkey 2 to send the four intermodulation distortion test tones at the level displayed. On a two-wire circuit, another 930A or a test set with Intermod Distortion measuring capability must be at the distant end.

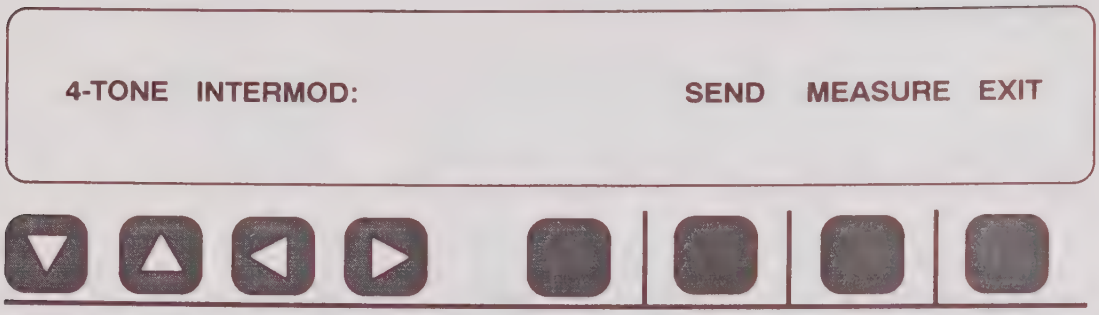
If a transmit level other than the default value of -13 dBm is desired, simply enter the new value using the numeric keypad. Press the ENT(Enter) key after the new level has been keyed in. The range of permissible values for the send levels vary with trunk type selected. These values are:

Analog: -40 dBm to +0 dBm
PCM: -40 dBm to -6 dBm

The Model 930A will prevent entry of levels outside those specified above.

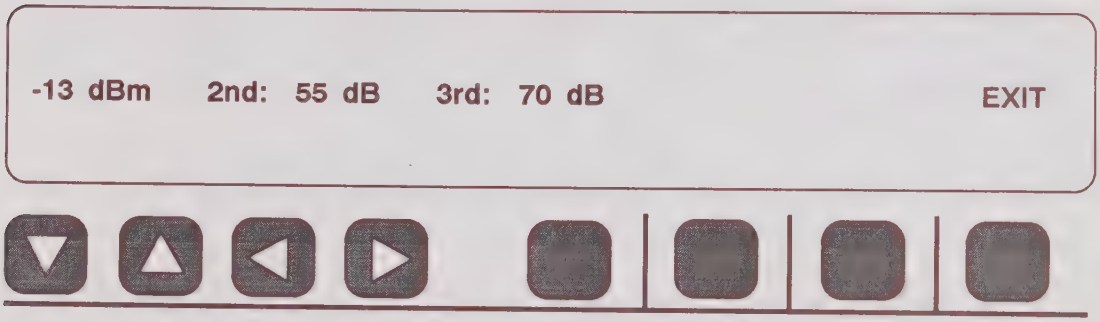
Press Softkey 4 to exit back to the main IMD menu. This will not interrupt the tones being sent. It will bring the user back to the main menu so that the test can be either terminated or the MEASURE mode can be selected if testing on a four-wire looped back circuit.

After pressing Softkey 4, the 930A display will return to:



Pressing Softkey 4 (labeled EXIT) will terminate testing. Pressing Softkey 3 (labeled MEASURE) enables the 930A to measure the Intermodulation Distortion present on the trunk under test. This will not disable the tones being sent under the SEND sub-menu unless a two-wire trunk type has been selected.

Pressing Softkey 3 (labeled MEASURE) will bring up the IMD measurement display. A typical display is shown below:

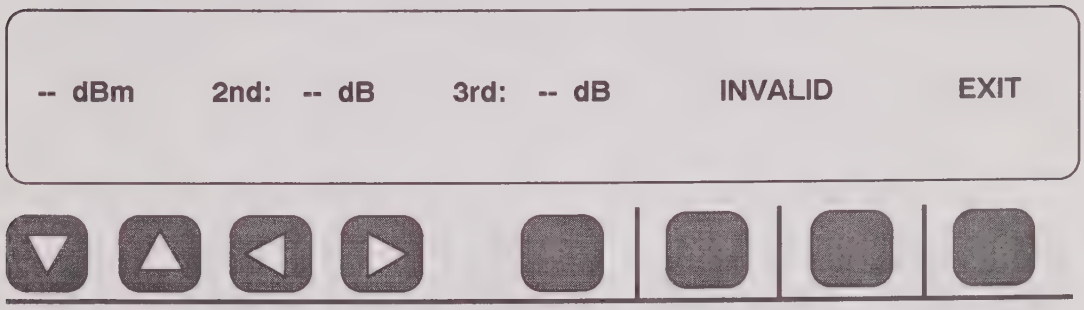


The first field in the above display (labeled -13 dBm) shows the composite received level of the four IMD tones in this example. If no signal is present this field will be blank. The second field (labeled "2nd: dB") is the level at which the second order IM products are being received below the level of the four IMD tones. In this example the second order products are 55 dB below the IMD tone level of -13 dBm for a total of -68 dBm. Similarly, the third field (labeled "3rd: dB") is the level at which the third order IM products are being received below the -13 dBm signal level.

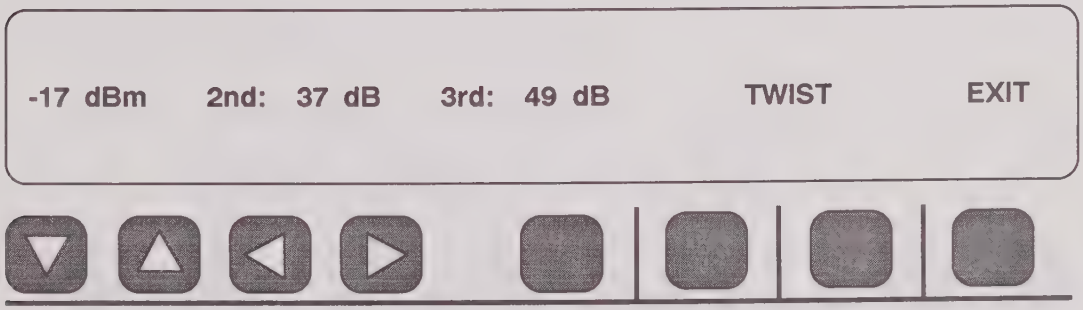
The gap between the third field and the word "EXIT" is reserved for messages.

These messages are:

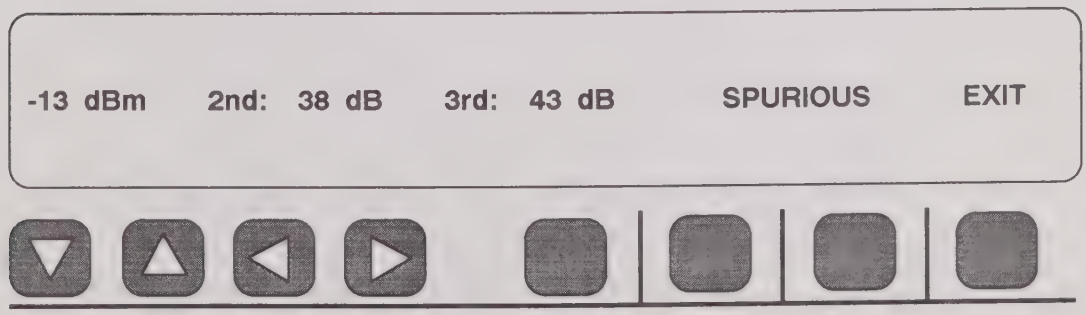
1. The message "INVALID" indicates an invalid signal; i.e., the IMD signal is absent, the level is below -40 dBm, or too high for the circuit (>0 dBm in analog, >-6 dBm in PCM). A typical display is shown below:



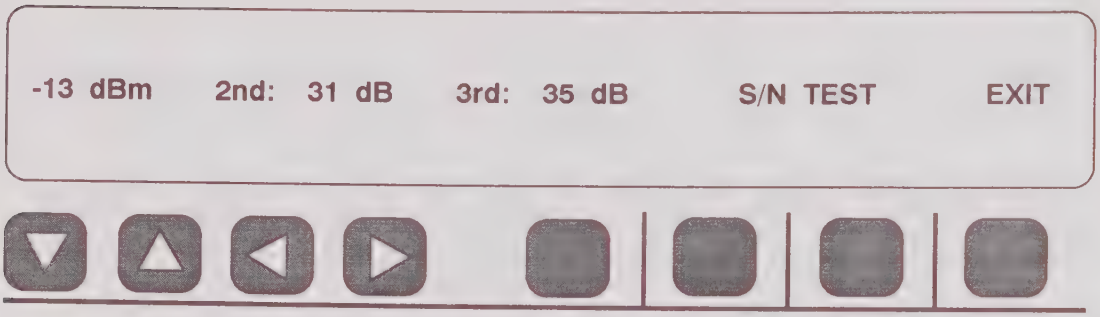
2. The message "TWIST" indicates that the IMD tones are being received at unequal levels (i.e., they differ by more than 6 dB from each other). A sample display is shown below:



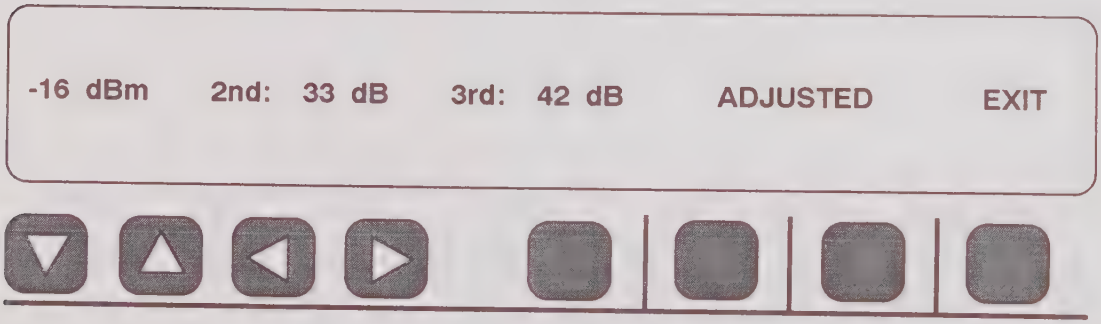
3. The message "SPURIOUS" indicates the presence of a spurious tone (any tone other than the four test tones). A typical display follows:



4. The message "S/N TEST" shows that the 930A is receiving the signal-to-noise test tones. The fields labeled "2nd: dB" and "3rd: dB" now contain noise measurements where the distortion products used to be. The measurements are in dB below the received signal as a S/N ratio. The display will appear as:



5. The message "ADJUSTED" indicates that the distortion measurements are being corrected automatically for signal-to-noise ratio. A typical display is:



In order for the 930A to automatically correct the IMD measurements for Signal-to-Noise ratio, the 930A must have first received the Signal-to-Noise tones and must now be receiving and measuring the IMD tones. The displayed distortion is obtained from the following formula:

$$\text{Displayed Distortion} = Y + (-10 \log (1 - 10^{-.1X}) \text{ dB})$$

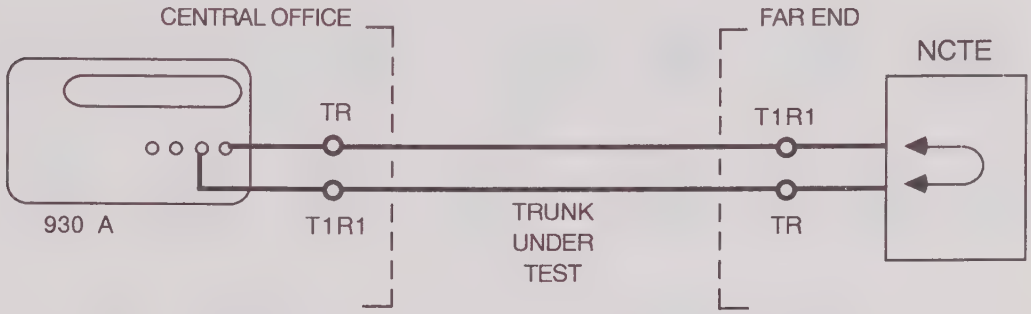
Where the Signal-to-Noise reading is X dB above the observed distortion Y.

The following example of a corrected IMD test performed on a four wire circuit will serve to clarify the procedure.

4-10.1 CORRECTED IMD TEST ON A FOUR-WIRE CIRCUIT

The following example illustrates the procedure involved in performing a corrected four-tone Intermodulation Distortion measurement with the 930A.

For this example, assume that the trunk to be tested is a 4-wire circuit. It is also assumed that there is Network Channel Terminating Equipment (NCTE) at the far end which is capable of providing a loopback on the line. A typical circuit diagram is shown below:



The following steps outline the procedure:

1. Select the correct Trunk Type on the 930A as described in Section 3-6 and connect the appropriate test cords as shown in Section 3-4.5.

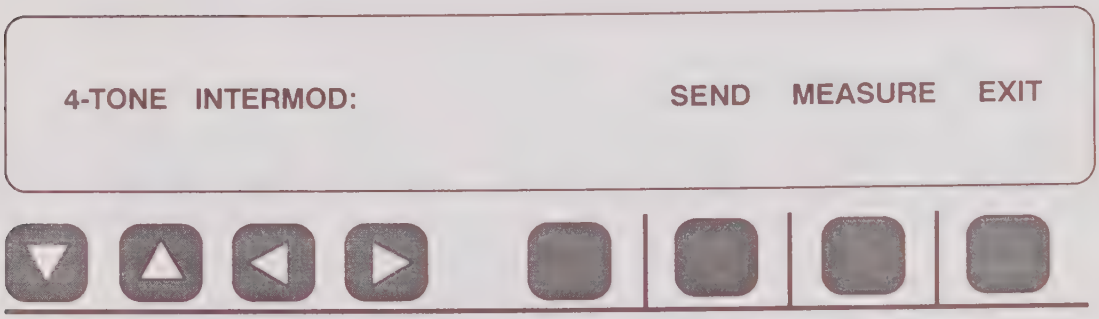
2. If the trunk under test is a dedicated line and not a dial up line proceed to step 3. If not, press the Dial/Ring function key, go Off Hook, and dial the far end loopback device's number. Refer to Section 3-7 for dialing instructions.

3. Press the Send Tone function key and set the 930A to send 2713 Hz at -10 dBm for 5 seconds. Refer to Section 3-9 for Send Tone instructions.

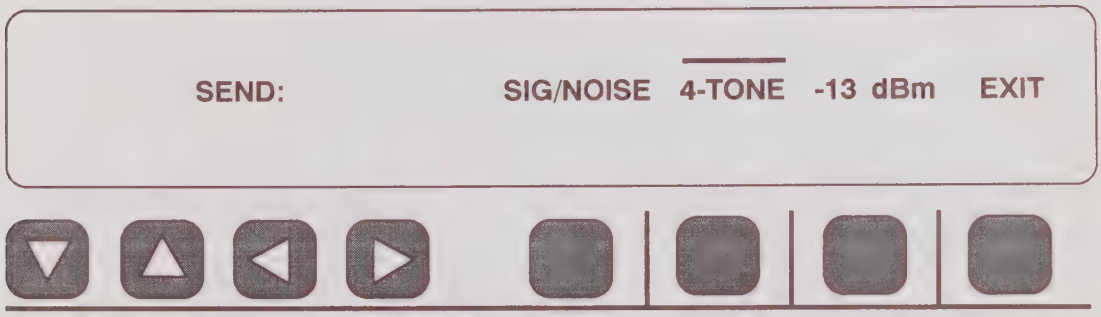
4. Press the Measure Tone function key and when the line is looped, the 2713 Hz tone will be displayed and the tone will be audible.

5. When the line has been looped back, press the Send Tone function key again and then press Softkey 4 to turn off the 2713 Hz tone.

6. Press the Option Menu function key and then use the numeric key pad to enter 1 and 9. Press the ENT (Enter) key to enter the numbers. The 930A display will become:

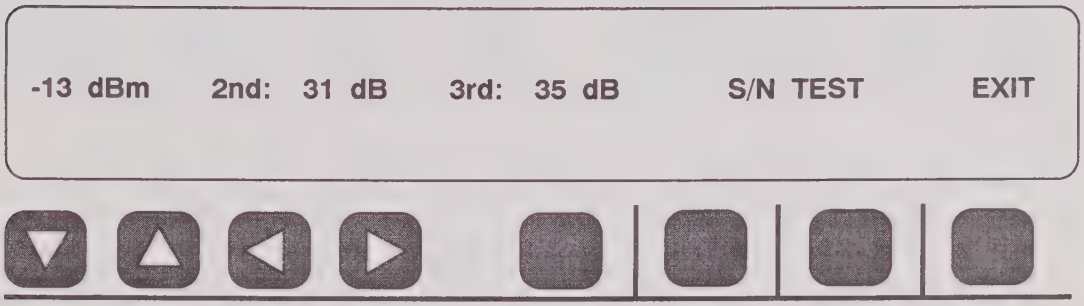


7. Press Softkey 2 to select SEND. The 930A display will change to:

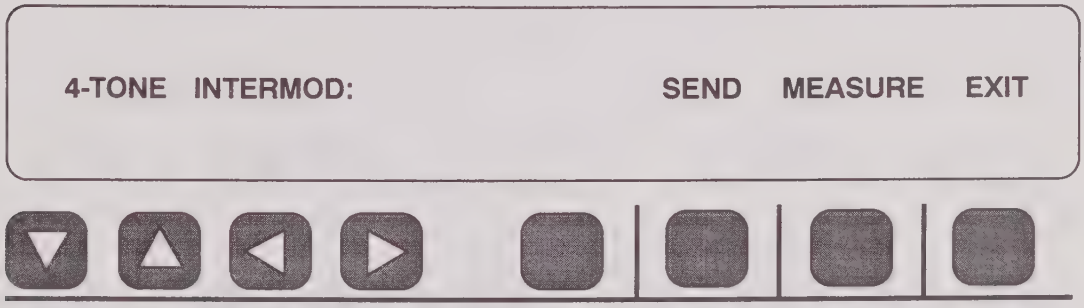


8. Press Softkey 1 to select Signal-to-Noise, set the level to -13 dBm if it is not at that level, and press Softkey 4 to Exit to the main menu. The 930A is now sending the Signal-to-Noise test tones.

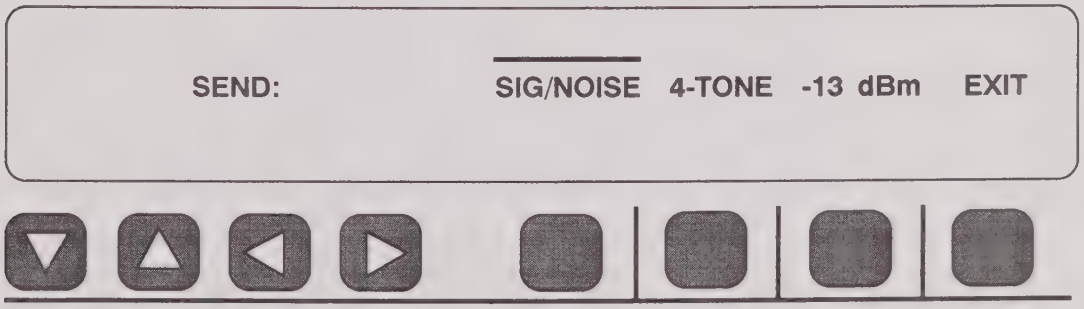
9. Press Softkey 3 to select MEASURE. Wait for a few seconds for the measurements to stabilize. The received level and the fields labeled "2nd: dB" and "3rd: dB" will contain test results. A typical display will be:



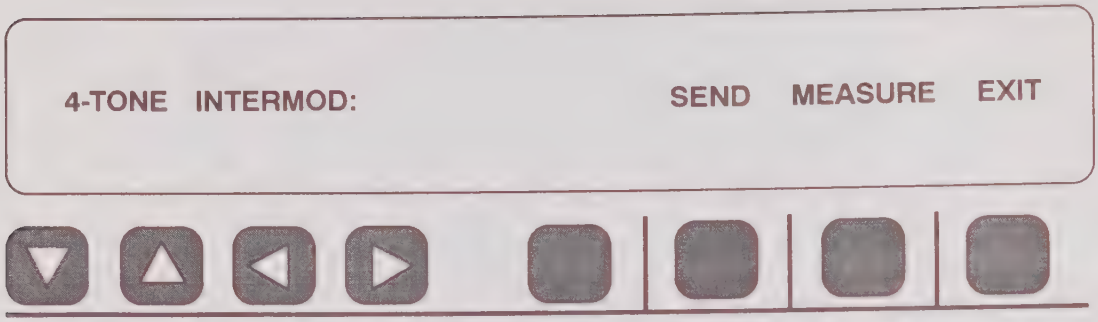
10. Press Softkey 4 to Exit back to the main menu.



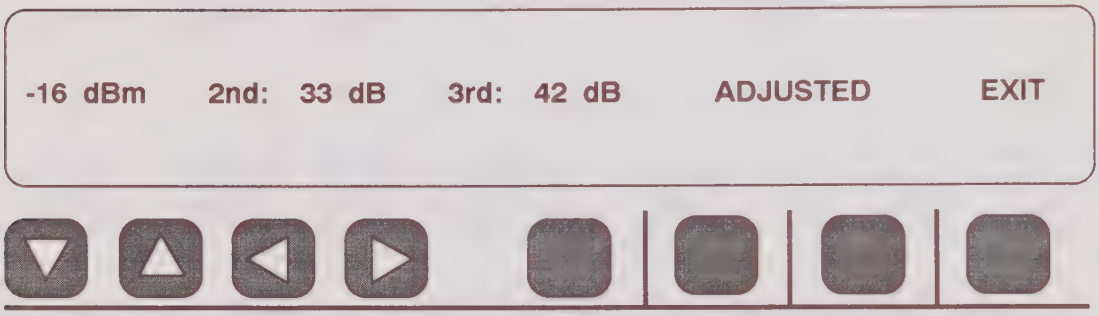
11. Press Softkey 2 to select SEND.



12. Press Softkey 2 to select 4-TONE and the 930A now sends the IMD test tones at -13 dBm. Press Softkey 4 to exit back to the main menu.



13. Press Softkey 3 to select MEASURE. Wait for a few seconds for the measurement to stabilize. There should be stable readings of the second and third order intermodulation products. The word "ADJUSTED" should appear to the left of the word "EXIT". A typical display of corrected Intermodulation Distortion products will appear as shown in the example below:



14. Before going back On Hook, press the Send Tone function key and send the 2713 Hz tone again to release the loopback. When this has been accomplished, place the 930A Hookswitch in the On-Hook position to terminate testing.

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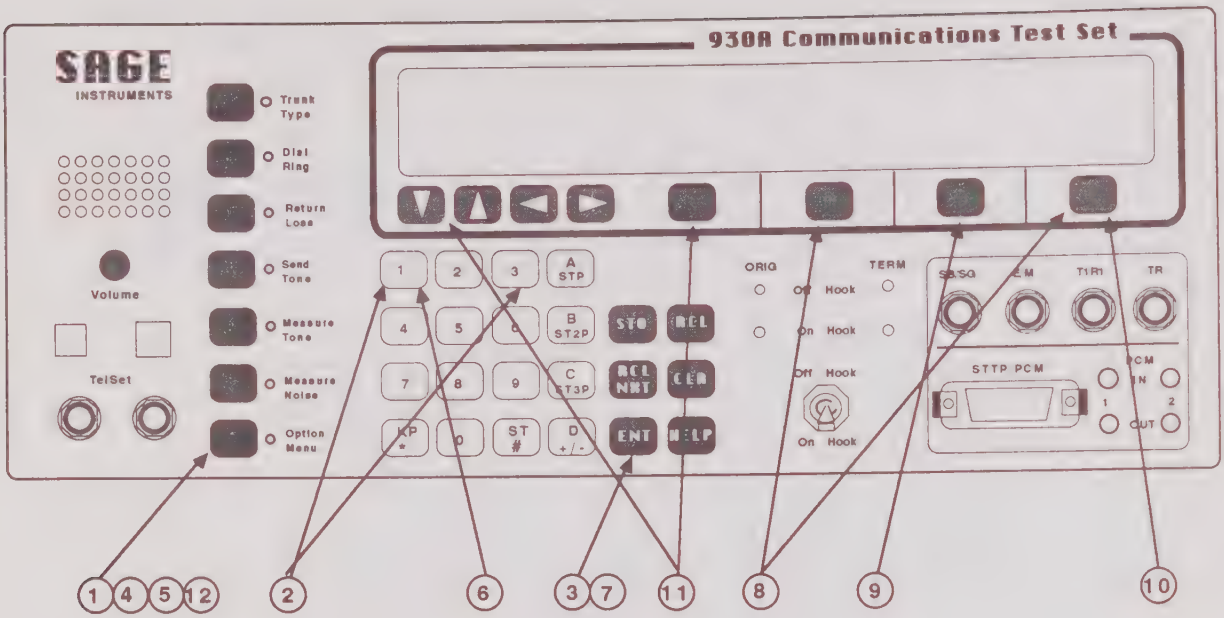


To select Phase/Amplitude Jitter measurement:

1. Press the OPTION MENU function key.
2. Use the numeric keypad to enter the number 13.
3. Press the ENT(Enter) key to begin Phase/Amplitude Jitter measurements.
4. Press the OPTION MENU function key to stop measurements and Exit.

To select Phase Hits, Gain Hits and Dropouts measurement:

5. Press the OPTION MENU function key.
6. Use the numeric keypad to enter the number 11.
7. Press the ENT(Enter) key to complete the numeric entry.
8. Press Softkey 2 (DEFAULT) to select DEFAULT Impulse Noise and Hits parameter values or press Softkey 4 (SET-UP) to manually change individual parameters.
9. Press Softkey 3 (MEASURE) to enter measurement mode.
10. Press Softkey 4 to start or stop measurements.
11. Press Softkey 1 or the UP/DOWN arrow keys to toggle between Impulse and Hits measurements displays.
12. Press the OPTION MENU function key several times to exit.

PHASE/AMPLITUDE JITTER OPTION
FIGURE 4-20

4-11 PHASE/AMPLITUDE JITTER AND HITS (OPTION 930A-18)

Option 930A-18 works in conjunction with Option 930A-07 (Impulse Noise) to provide the capability to measure Phase and Amplitude Jitter on Voice Frequency channels as well as transient phenomena such as Phase Hits, Gain Hits, and Dropouts. Phase and Amplitude Jitter are displayed under option menu 13 while the transients are displayed with the Impulse Noise counts under option menu 11.

The measurement of Phase and Amplitude Jitter or Hits is only of concern on trunks carrying voice band, or Modem, data. Most modern Modems employ either Phase Shift or Frequency Shift Keying modulation techniques. These are particularly susceptible to impairments such as Phase Jitter or Hits. Speech itself is relatively insensitive to these impairments so a line which supports voice may be incapable of passing data.

Phase/Amplitude Jitter and Hits are measurements which are made with a holding tone (usually 1004 Hz) present on the trunk under test. While these measurements could be made on a looped back circuit they are generally valid only as an end-to-end measurement.

Phase and Amplitude Jitter are measured over certain bandwidths. These bandwidths are:

Low Frequency	4 Hz to 20 Hz
Standard	20 Hz to 300 Hz
Standard + Low Frequency	4 Hz to 300 Hz

The Phase and/or Amplitude Jitter present on the received holding tone is measured over one or more of these ranges. The source of the jitter can often be determined by the band in which it is most prominent.

Phase Jitter is measured in degrees while Amplitude Jitter is measured as a percent deviation from the 1004 Hz holding tone's reference level which is usually -13 dBm0.

Phase Hits, Gain Hits, and Dropouts are counts of events which exceed certain thresholds in much the same way Impulse Noise bursts are counted.

The difference lies in the fact that the event must also be present for a period of time greater than some predetermined minimum in order to be counted as a Hit or Dropout. So there are two thresholds involved.

Phase Hits are counted when a change in phase of the holding tone exceeds the threshold for a period of time longer than the qualification interval. These intervals and thresholds are described in detail in IEEE Std. 743-1984 which is now the controlling document (following the divestiture of AT&T). In essence however, the phase thresholds vary from 5^0 to 45^0 (usually in 5^0 steps) and the time period threshold is expressed in terms of the holding tone period. It is roughly 4 milliseconds. So, to be counted as a Phase Hit, the change in phase must exceed the phase threshold for more than 4 milliseconds. The change in phase may be either positive or negative.

Similarly, Gain Hits are counted when a change in the amplitude of the holding tone exceeds a preset threshold for longer than the qualification interval. The change may be an increase or a decrease in amplitude. The threshold settings are usually 2 dB, 3 dB, 4 dB, 6 dB, 8 dB and 10 dB. Again, the qualification interval is roughly 4 milliseconds.

Dropouts are counted when the level of the received holding tone decreases by at least 12 dB for a period of time greater than the qualification interval. The 930A measures the level of the received holding tone at the beginning of the measurement and uses this value as its reference. A dropout is declared if the received holding tone level drops 12 dB or more from this reference for more than 4 milliseconds. Anything less than 4 milliseconds shows up under the Impulse Noise menu option.

Since the Phase and Amplitude Jitter measurements are displayed under option menu 13 and the Hits are counted with Impulse Noise under menu 11, this Section is divided into two parts: Paragraph 4-11.1 deals with Jitter and Paragraph 4-11.2 deals with Hits.

As always, the user must first select the correct Trunk Type (Refer to Section 3-6) and connect the 930A to the trunk under test prior to setting up these measurements. In the case of Phase Jitter measurements however, **it is also necessary to perform a C-Message Noise measurement prior to measuring Phase Jitter since excess noise can cause what appears to be significant amounts of jitter.**

4-11.1 PHASE/AMPLITUDE JITTER MEASUREMENT

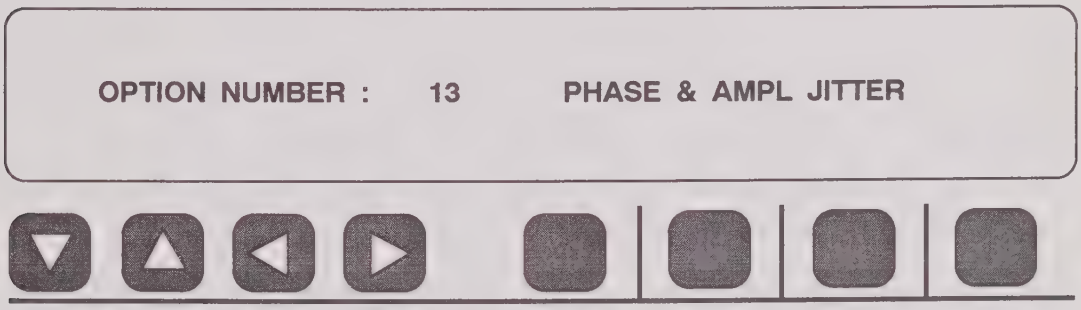
After performing the C-Message noise test as outlined in Section 3-11 (readings should be less than 20 dBrnC for quiet terminated line) perform the following steps to place the 930A in the Phase/Amplitude Jitter mode:

Press the OPTION MENU function key.

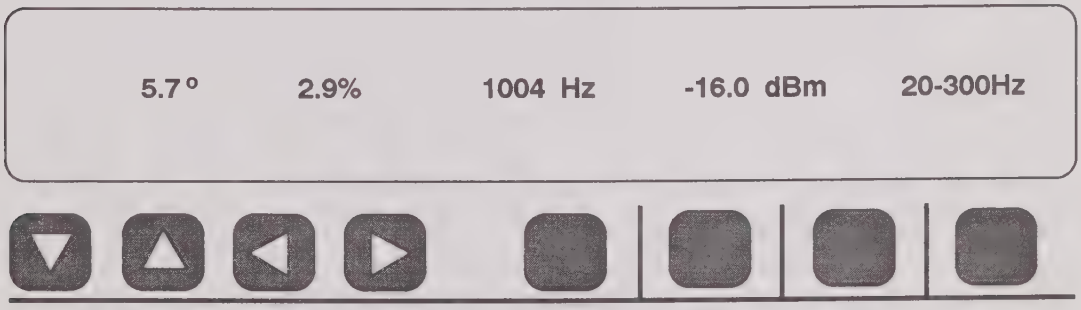
Use the UP/DOWN arrow keys to

select Menu Option 13: PHASE & AMPL JITTER.

The Model 930A display will appear as shown below:

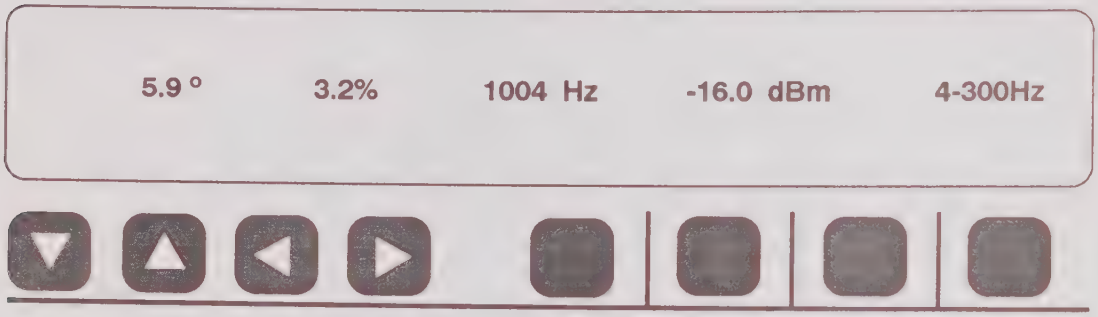


Press any Softkey to begin Phase and Amplitude Jitter measurements and the 930A display will, after a time, resemble:



The 930A begins measuring Phase and Amplitude Jitter over the filter bandwidth of 20 Hz to 300 Hz. It also displays the level and frequency of the received holding tone (usually 1004 Hz).

Obviously there is a good deal of phase jitter on the trunk in this example. The full jitter measurement bandwidth (4-300 Hz) provides an overall picture of the jitter situation. The next step is to try to determine the source of the jitter. To do this, press Softkey 4 (under "20-300 Hz") to change the filter bandwidth selection from 20-300 Hz to 4-300 Hz and now assume that the 930A displays the following measurements:

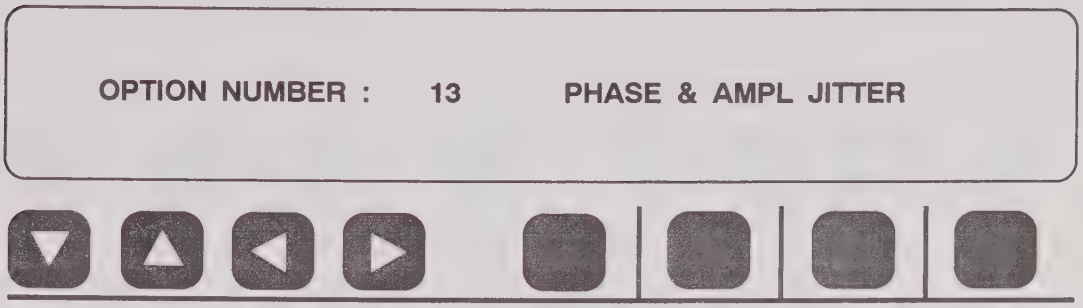


In this case there is not a significantly lower reading in either the 4-300 Hz or 20-300 Hz bands. The interpretation of these results is relatively straightforward now that the measurements have been made. The fact that the readings are relatively the same suggests that the source of the excess jitter has a fundamental frequency above 20 Hz since there are no significant contributions to the levels below 20 Hz.

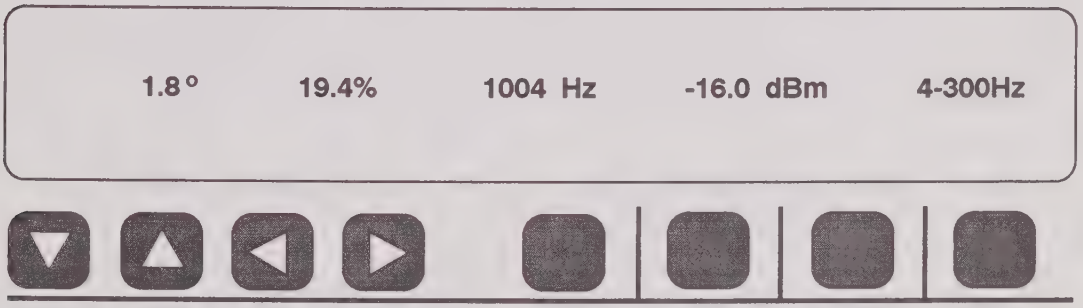
Between 20 Hz and 300 Hz the most significant source of jitter is the 60 Hz AC power line frequency and its second through fifth harmonics (120 Hz, 180 Hz, 240 Hz, 300 Hz).

There is a good chance that making the C-Message Noise test prior to the Jitter test would have provided a tip-off to the problem also. Since the Model 930A has a frequency response down to 50 Hz (20 Hz on PCM trunks), it is also possible that the operator could determine the exact frequency of the jitter source by simply pressing the Measure Tone function key and noting the displayed frequency value when the holding tone is removed. If the jitter source is of sufficient amplitude, it will be displayed. If not, then the operator must assume that the source is 60 Hz or a harmonic of 60 Hz and proceed to troubleshoot on that assumption.

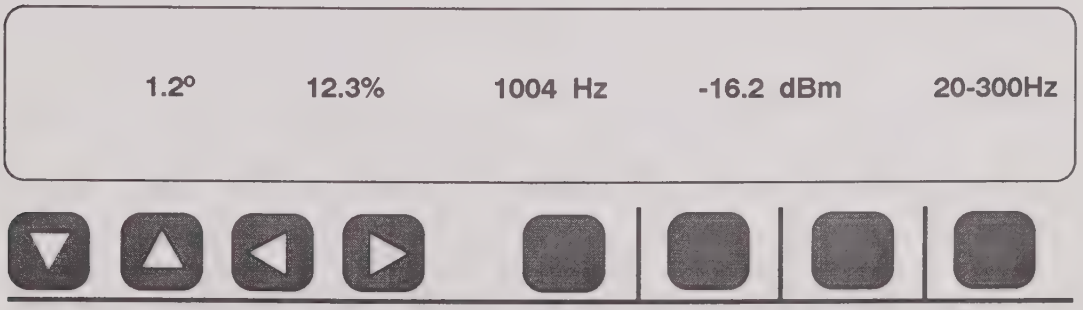
To stop testing and return to the main menu press the OPTION MENU function key. The 930A display will return to:



Another example of Phase and Amplitude Jitter measurement with the 930A when the results are less clear cut follows. Pressing any Softkey in the above display will enter the menu option and begin testing. Suppose that, for this example, the measurement display now appears as:

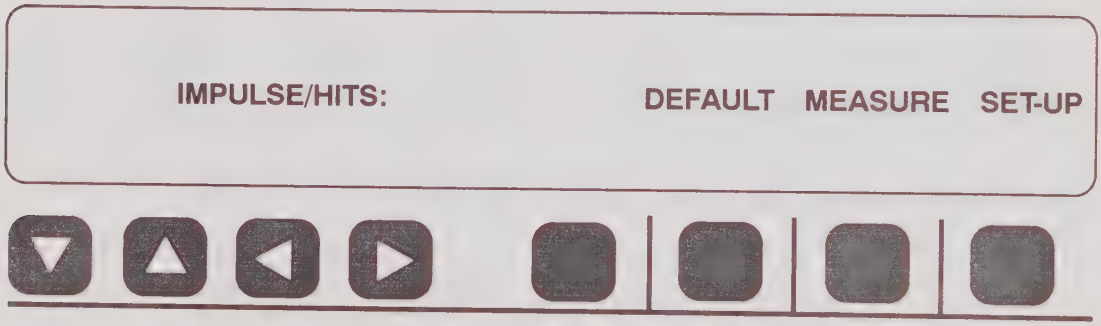


Here there is not much Phase Jitter but there is considerable Amplitude Jitter. The next step is to try to pin down the source by reducing the bandwidth of the measurement. Pressing Softkey 4 (labeled "4-300Hz") above advances the 930A display to that shown below:



Softkey 2 sets all the test parameters such as thresholds and time intervals to the factory defaults. Pressing Softkey 2 causes the 930A to momentarily display the message:

The 930A display will then return to:

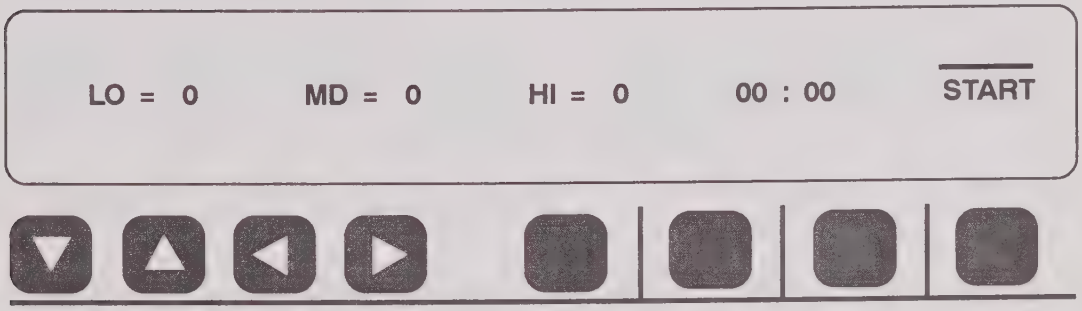


This also provides a convenient way to restore previously entered settings to the factory default values by pressing Softkey 2 in the above display.

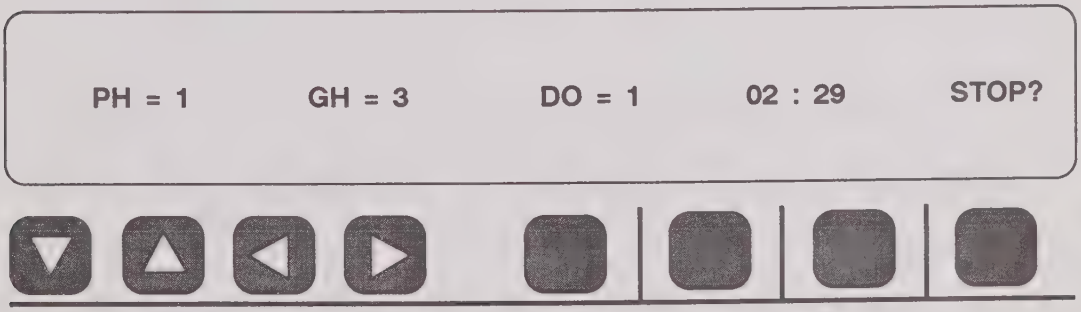
At this point, the user need only press Softkey 3, labeled "MEASURE", to enter the measurement mode and the display will appear as shown on the following page.

The factory defaults are:

C-Notch filter for measurement with holding tone
Low Impulse Threshold is 54 dBrnC (Metallic trunks)
Low Impulse Threshold is 67 dBrnC (T-Carrier trunks)
Spread between thresholds is 4 dB
Measurements per second is 7
Phase Hit threshold is 20^{o}
Gain Hit threshold is 3 dB
Test Duration is 15 minutes

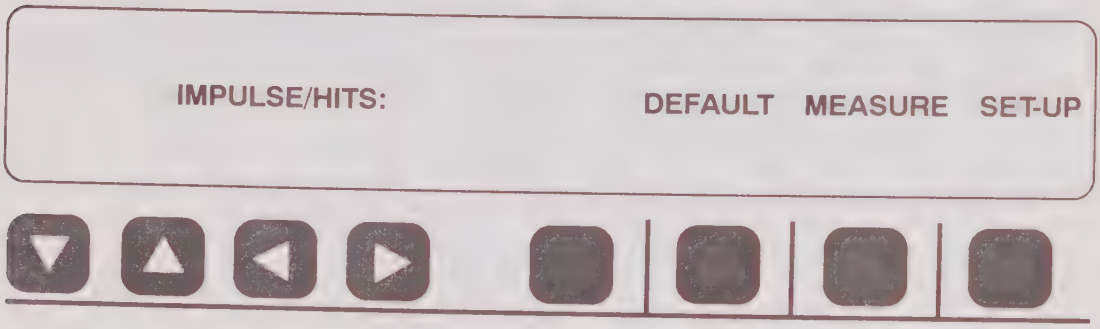


At this point it is only necessary to press Softkey 4 labeled "START" to begin measuring Impulse Noise and Hits. To see the Hits measurements, simply press Softkey 1, any of the arrow keys or Softkeys 2 or 3 and the display will toggle between Impulse Noise and Hits. For example, the Hits display might appear as shown below:

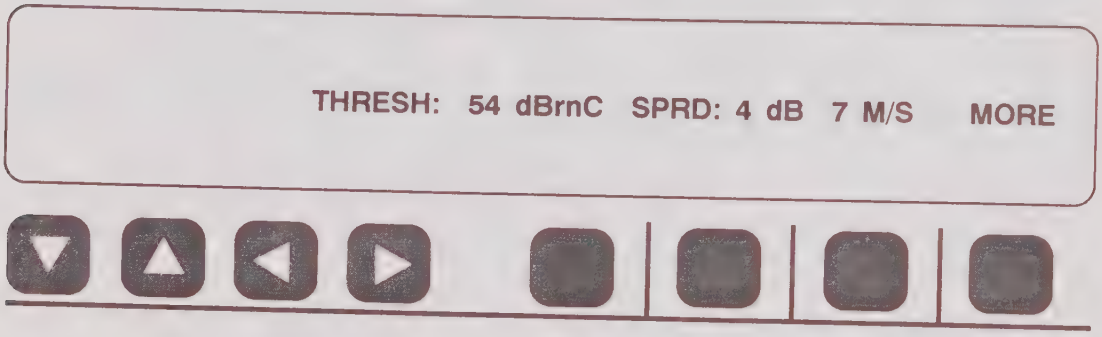


This is the easy way to make measurements of Hits and Impulse Noise.

However, there may be times when the user needs to set one or more of the parameters individually. This is where it becomes necessary to enter the SET-UP mode. The Set-Up procedure for the Impulse Noise Parameters (Low Threshold, Spread, Measurements per Second and Measurement Time) is described in detail in Section 4-5. The main display is repeated below:

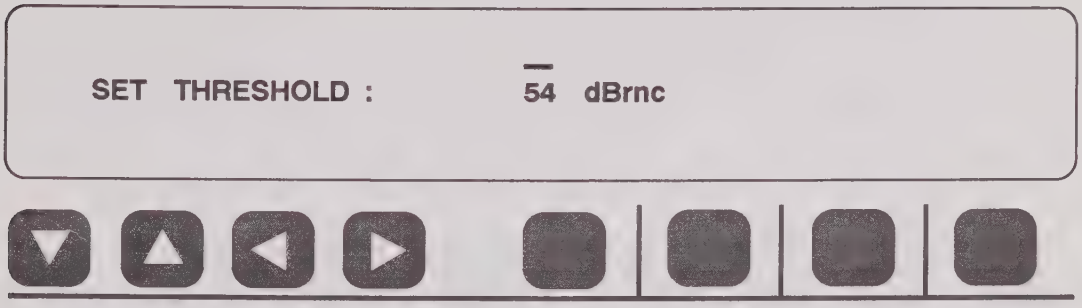


Instead of pressing Softkey 2 to set all the parameters at once, pressing Softkey 4 labeled "SET-UP" causes the following display to appear:

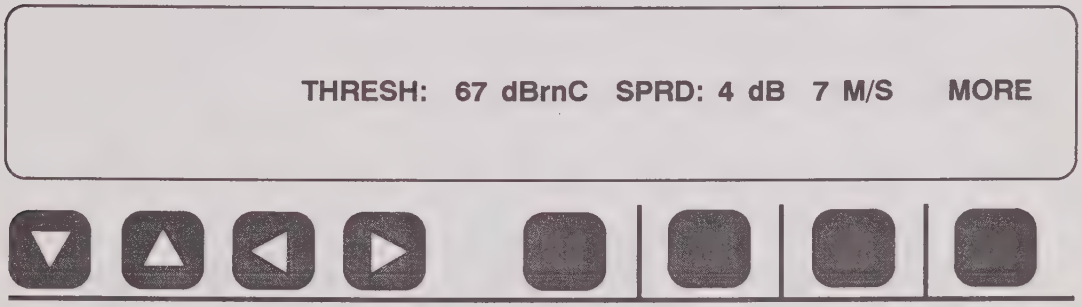


The Set-Up of the Impulse Noise and transient (HITS) parameters consists of selecting the Low Impulse Threshold, Phase Hit and Gain Hit thresholds and test duration. For example purposes, suppose that a portion of the end to end circuit being tested is carried on T-Carrier facility and part is on metallic facility. Since this is a mixed circuit the low threshold should be set to 67 dBrnC.

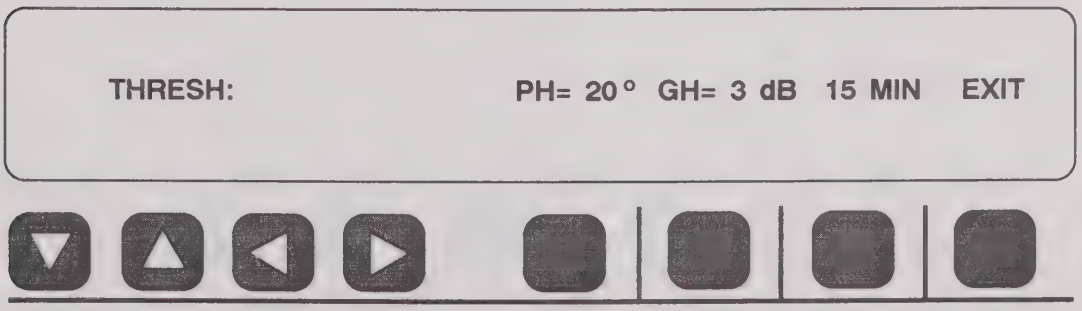
Press Softkey 1 (labeled THRESH: 54 dBrnC) in the previous display and the 930A display will change to:



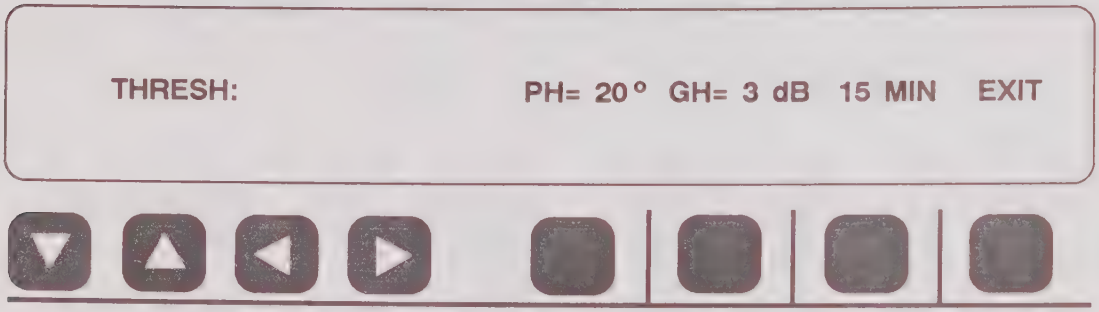
This shows the latest value of 54 dBrnC and now all that is necessary is to press 6 and 7 on the numeric keypad and then press the ENTER key to complete data entry and the 930A display will now show:



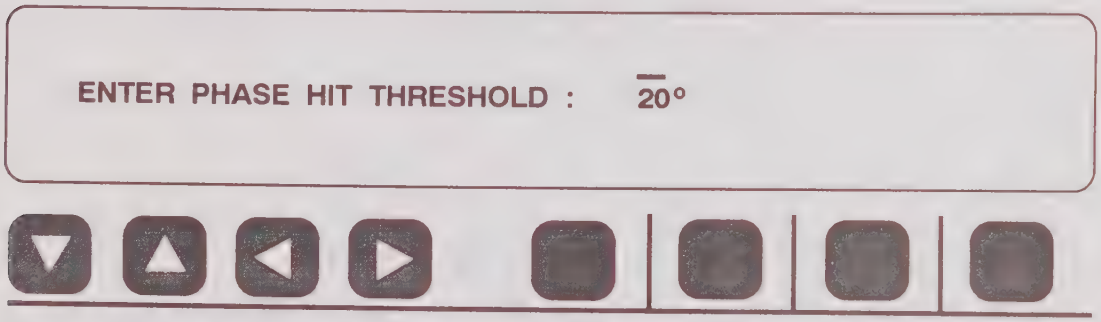
Now the low threshold would be 67 dBrnC and since the spread is set at 4 dB the medium threshold would be 71 dBrnC and the high threshold would now be 75 dBrnC. The 4 dB spread and 7 measurements per second are the standards but they can be changed in the same manner as the low threshold by pressing the softkeys under them and entering the change. Press Softkey 4 (labeled MORE) to advance to the transient set-up menu shown below:



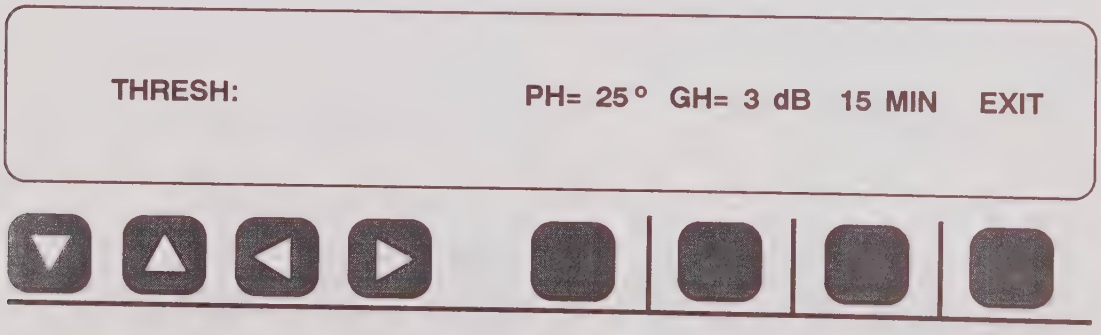
In this Section we are concerned with setting up the Transient or Hits thresholds so press Softkey 4 labeled "MORE" and the 930A display becomes:



Suppose, for example that a Phase Hit threshold of 25° was desired instead of the default value of 20° shown above. In this case, press Softkey 1 (labeled PH = 20°) and the 930A display will change to:

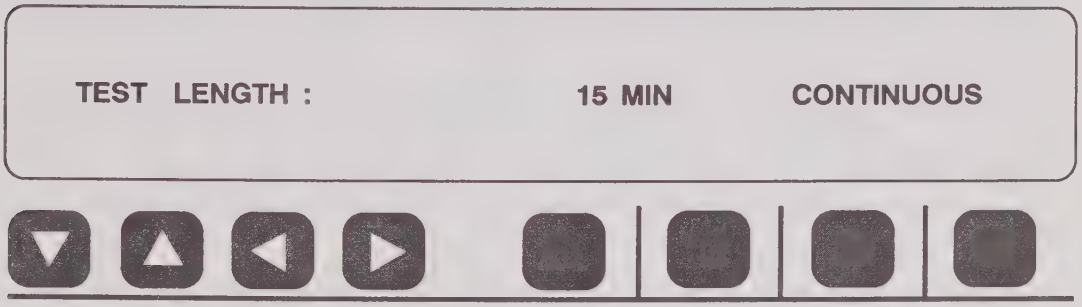


The numeric keypad can be used to enter any value between 1° and 45°. Then pressing the ENT (Enter) key completes the data entry. The display will return to the Set-Up menu with the new value of Phase Hit threshold entered. In this example a value of 25° is desired and so the operator would simply press 2 and then 5 and then the ENTER key and the display would change to:

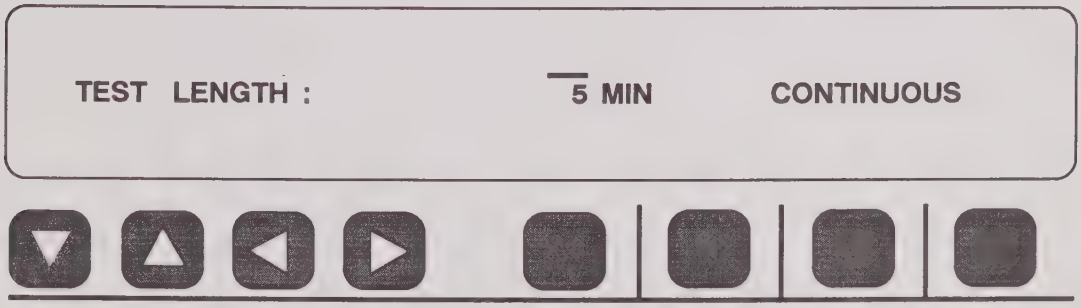


Similarly, the Gain Hit threshold and Test duration can be changed by pressing Softkey 2 (Gain Hit) or Softkey 3 (Test time in minutes). Pressing Softkey 4 (EXIT) returns the 930A to the main menu to begin testing.

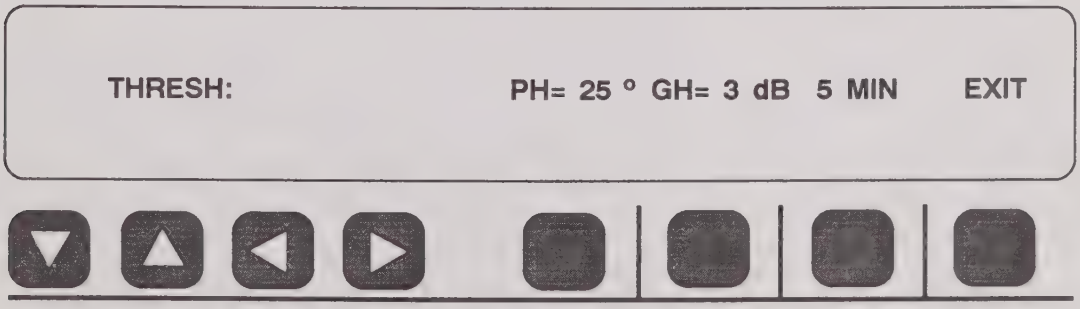
If the time duration of the test is to be shortened to 5 minutes instead of the standard 15 minutes then pressing Softkey 3 (labeled 15 MIN in the previous display) would bring up the following:



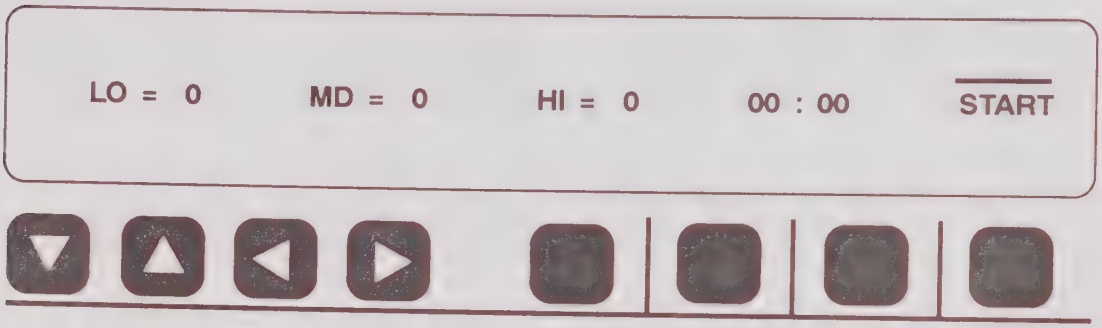
Pressing Softkey 3 above would cause the 930A to measure continuously. Since it was desired to shorten the test time to 5 minutes for this example it is only necessary to press 5 on the numeric keypad so the display appears as:



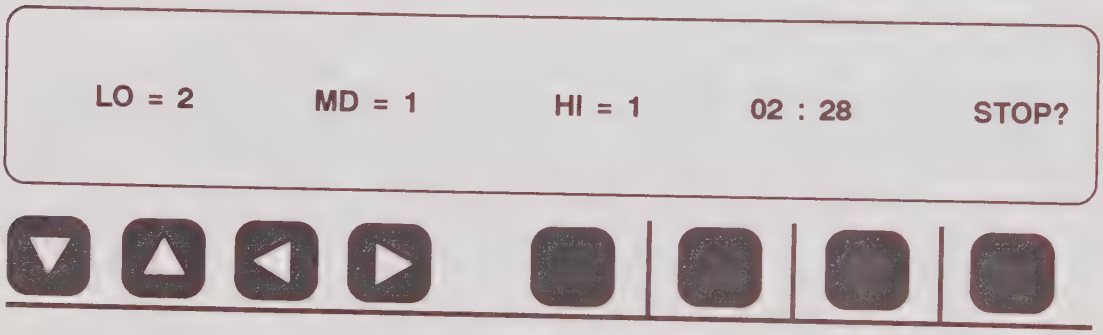
Now pressing the ENTER key completes the data entry and returns the 930A to the set-up display which now looks like:



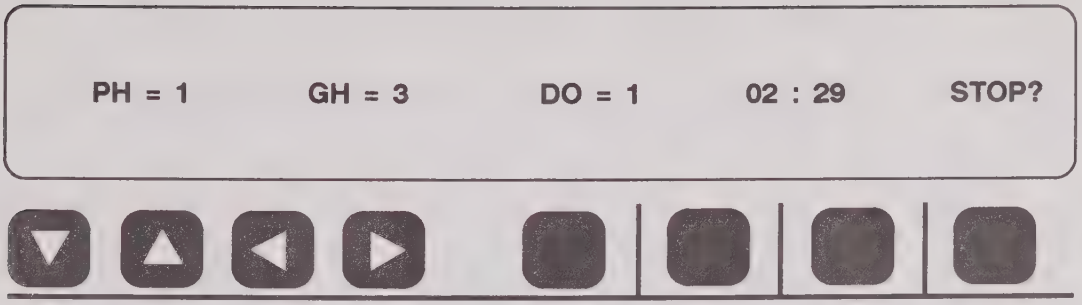
Pressing Softkey 4 exits to the measurement mode to enable testing to begin and the 930A display appears as:



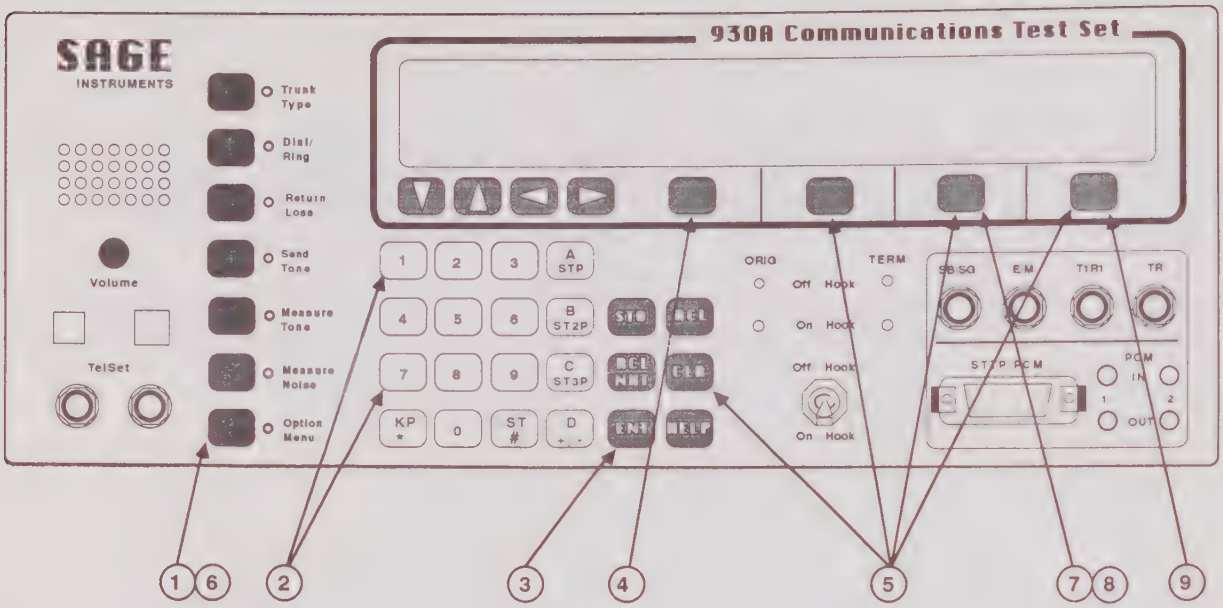
Press Softkey 4 (labeled START) and the 930A will begin measuring Impulse Noise and Hits. After a time a typical display would appear as shown below:



Pressing Softkey 1 or the UP/DOWN arrow keys enables the operator to toggle between displays of Impulse Noise counts and Hits. A typical display of the Hits counters is shown on the following page.



Pressing Softkey 4 (labeled STOP?) will stop the measurement at any point otherwise the 930A will count events until the test time (usually 15 minutes) has elapsed. The 930A will retain the values shown on the counters until a new test is started by again pressing Softkey 4.



To select Envelope Delay Distortion measurement:

1. Press the OPTION MENU function key.
2. Use the numeric keypad to enter the number 17.
3. Press the ENT (Enter) key to enter the SELECT menu.
4. To change the test set-up parameters press Softkey 1.
5. Press Softkey 2 to enter the SEND or Master mode.
   Press Softkey 4 to set the zero reference delay.
   Press Softkey 4 again to begin frequency sweep.
   Press Softkey 4 again to stop the sweep.
   Press the CLR key to set the zero reference at another point if desired.
   Press Softkey 3 to toggle between send and receive displays.
6. Press the OPTION MENU key to exit to the SELECT menu.
7. Press Softkey 3 to enter the REPEAT or Slave mode.
8. Press Softkey 3 to toggle between send and receive.
9. Press Softkey 4 to start or stop sweep.

ENVELOPE DELAY DISTORTION
FIGURE 4-21

4-12 ENVELOPE DELAY DISTORTION (OPTION 930A-19)

When Option 930A-19 is installed in the 930A the operator can measure the amount of Envelope Delay Distortion on a trunk under test.

Envelope Delay Distortion (EDD) measurements make use of an Amplitude Modulated (AM) waveform to determine the relative phase shift over a trunk. This phase shift is converted into a measurement of the delay in time. Basically, a low frequency sinewave (usually 83 1/3 Hz) is used to AM a "carrier" (usually 1804 Hz). The amplitude modulation is received at the far end of the circuit. The received modulation is recovered and used to re-modulate a "carrier" (usually also 1804 Hz) which is then returned to the originating end via a separate path.

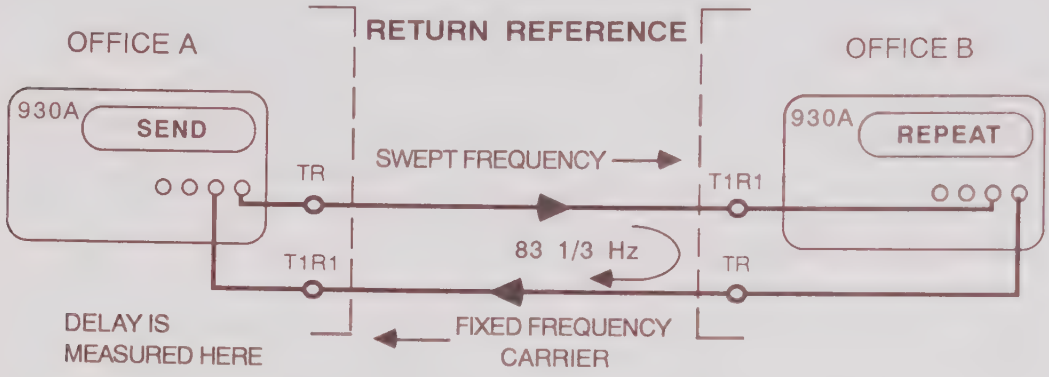
The test set at the originating end compares the phase of the returned modulation to the phase of the modulation it is sending and uses the difference to calculate the delay in microseconds. This becomes the "reference delay" and is used to compare the results at other frequencies. Once the reference has been set the originating test set then sends other frequencies with the same amplitude modulation (generally 83 1/3 Hz) superimposed. The delay at the other frequencies (304 Hz to 3504 Hz band) is returned to the originating test set in the same manner as the reference modulation over the separate path. This is known as a "Return Reference" measurement because the reference carrier is being returned from the far end. The originating test set then holds its modulated signal at a single frequency (usually 1804 Hz) while the far end sweeps through the band of frequencies (usually 304 Hz to 3204 Hz or 304 Hz to 3504 Hz). Again, the originating end compares the delay at these frequencies to the reference delay. This is called a "Forward Reference" measurement because the originating test set now supplies the reference to the far end.

The results of an envelope delay test are expressed as positive or negative microseconds of delay over a frequency sweep, relative to the reference delay (0 μsec by convention).

EDD is inherently an end-to-end test. It requires test sets at both ends of the circuit and a 4-wire transmission path. One end is set up REPEAT (or Slave) mode, and the other end is set up in SEND (or Master) mode. The SEND unit sends a single frequency to establish a reference delay. This delay is "zeroed out", and the SEND unit sends a frequency sweep, measuring delay in

microseconds relative to the reference. The SEND end then sends the reference frequency while the REPEAT end sweeps the returned carrier. All delay measurements are made at the SEND end.

The test proceeds as shown below:

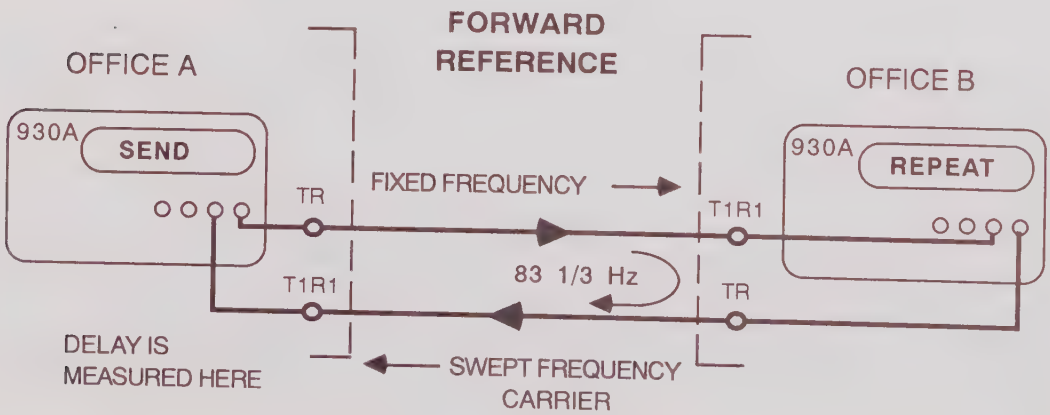


1) Office A sends an amplitude-modulated signal over the trunk under test.

2) Office B strips off the modulation and applies it to a carrier.

3) Office A recovers the returned modulation and compares it to that being sent. The difference in phase is proportional to the envelope delay.

4) The delay at a reference frequency is used as a zero reference, and a frequency sweep is then performed by the SEND unit. The delay at the other frequencies is measured in microseconds relative to the reference.



5) The SEND unit sends the reference frequency while the REPEAT unit sweeps the returned carrier. This allows the SEND unit to measure the delay on the return path.

4-12.1 ENVELOPE DELAY DISTORTION MEASUREMENTS

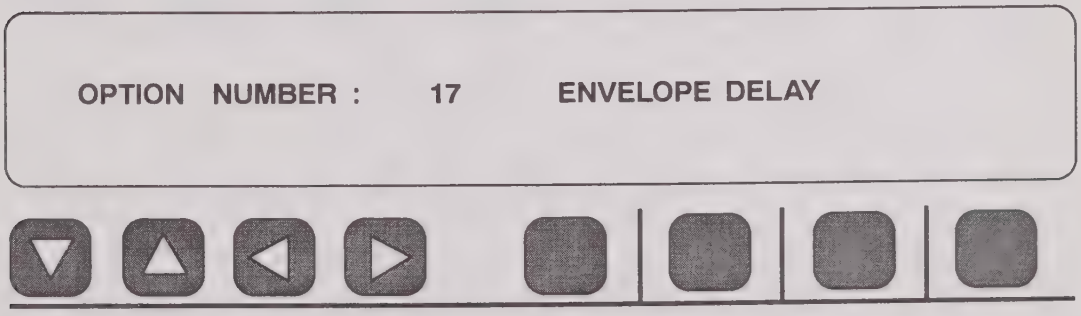
To make an Envelope Delay measurement perform the following steps:

Ensure that the 930A at each end of the circuit is set to the correct trunk type and impedance (Refer to Section 3-7). Use the **DIAL/RING** function to place a call over the trunk under test. With both units off hook in the **DIAL/RING** function, a voice path is available through the front panel TelSet jacks. A handset can be connected to allow coordinating the test activities with the far end if a separate voice path is not available. Decide at this point which unit will be the **SEND** end and which will be the **REPEAT** end.

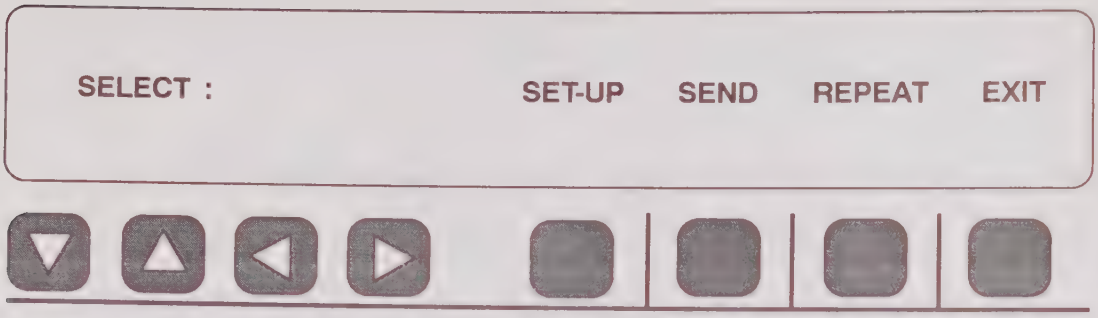
Press the OPTION MENU **Option Menu** function key.

Use the UP/DOWN arrow keys to select Menu Option 17: ENVELOPE DELAY.

The Model 930A display will appear as shown below:



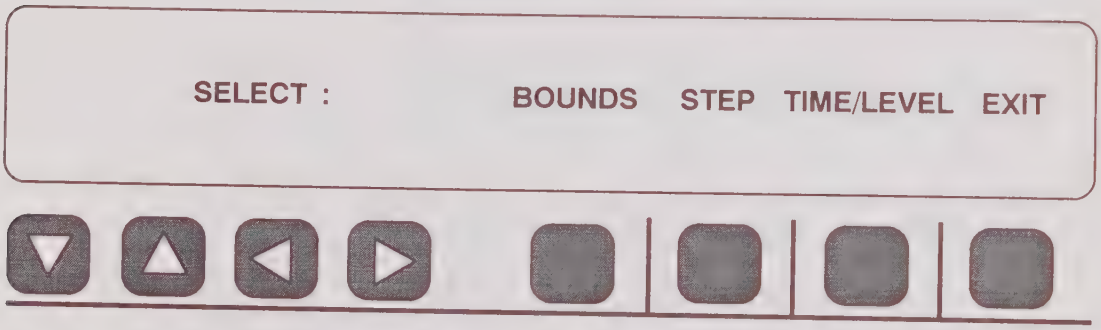
To enter the menu, press any Softkey and the 930A display will change to the display shown on the following page:



At this point the operator has the opportunity to change any or all of the test parameters or go directly to the measurement mode. If the test set-ups have been previously entered and have not been changed, then it is not necessary to reenter the set-up mode since the 930A remembers the test set-ups.

SETTING UP A SWEEP:

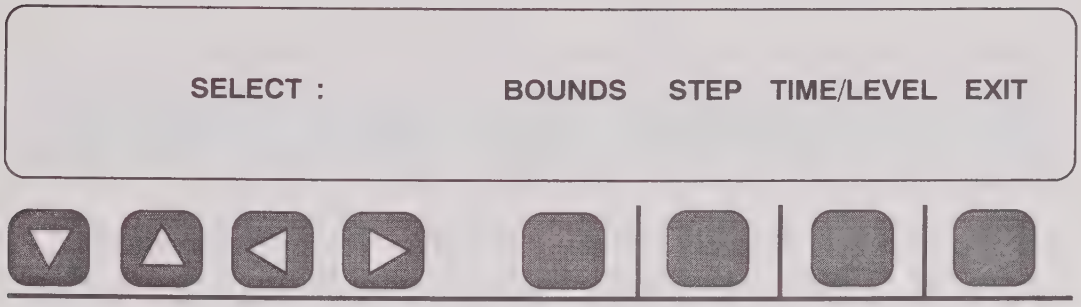
To enter the Set-Up menu, press Softkey 1 located under the words SET-UP on the 930A display. The display will change to:



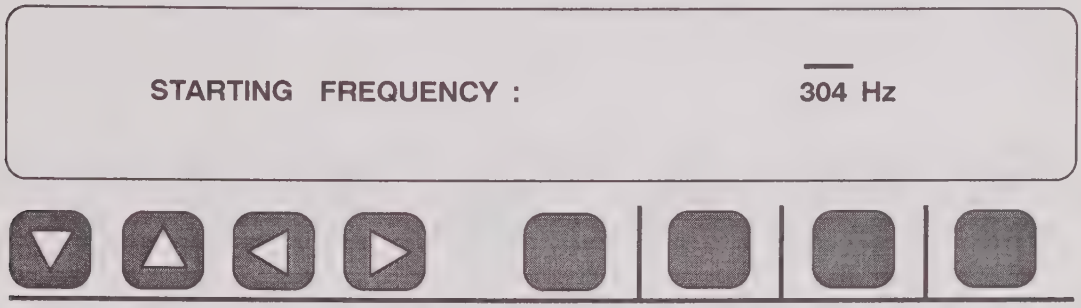
This is exactly the same menu as that which is used to set up Menu Option 10: FREQUENCY SWEEP in Section 3-12.4 on page 3-111. The 930A default parameters have been pre-set to sweep from 304 Hz to 3204 Hz in 100 Hz steps at a level of -16 dBm and a time between steps of 3.5 seconds with the SF frequency band skipped. A typical Envelope Delay measurement would use these parameters so ordinarily the operator does not need to enter the Set-Up menu.

However, some C-Conditioned line tariffs specify performance out to 3504 Hz. Also, older vintage test equipment operated at 5 seconds between steps and it is possible that a different test set than the 930A may be at the far end of the circuit. For these reasons it is good to know how to change test

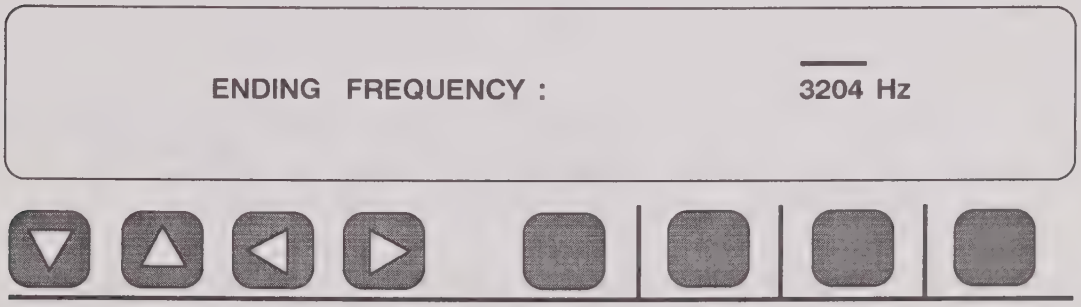
set-ups. To repeat a portion of Section 3-12.4, suppose it is desired to change the ending frequency bound from the 3204 Hz default value to 3504 Hz. The SELECT display is repeated below:



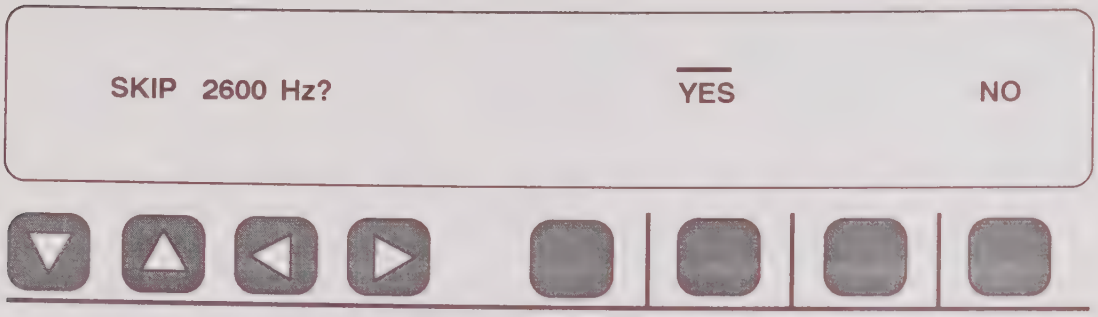
Pressing Softkey 1 (labeled "BOUNDS") will bring up the following display:



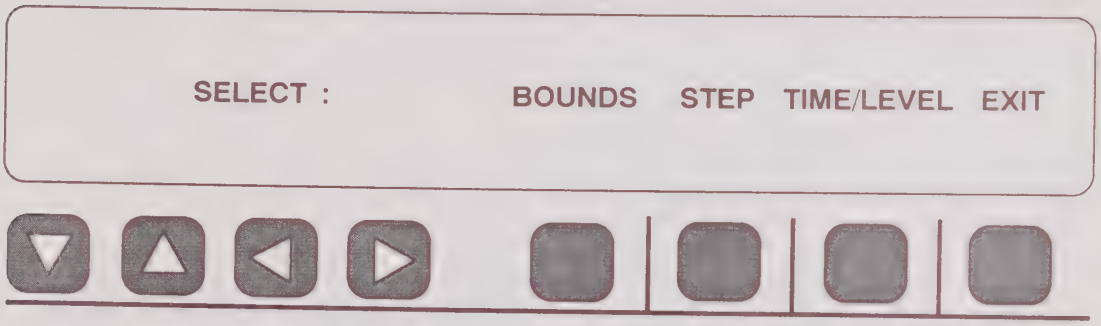
Since this is the desired starting frequency, press Softkey 3 (under "304 Hz") to accept this value and advance the display to:



This value is to be changed to 3504 Hz. Press 3, 5, 0 and 4 on the numeric keypad and then press the ENTER key to enter the value and advance to the Skip SF display shown on the following page.



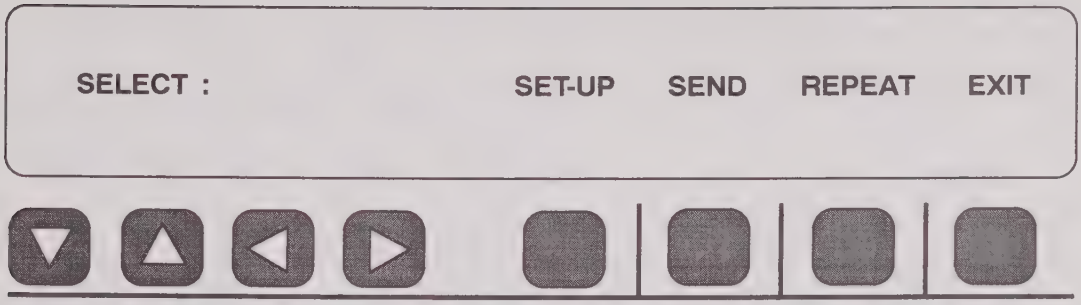
Normally the SF frequency plus a guard band of frequencies around it is skipped so pressing Softkey 2 in the above display will accept this condition and return the user to the SELECT display repeated below:



Similarly, the user may change the step size from 100 Hz to any value between 1 and 999 Hz, or the time between steps from 3.5 seconds to any value between 0.1 and 9.9 seconds. The level may be changed from -16.0 dBm to any value between 0 and -40 dBm.

Since this menu is taken directly from Menu Option 10: FREQUENCY SWEEP, levels may be entered from +12.0 dBm to -60.0 dBm and they will appear to be accepted. However, the 930A will only transmit over the 0 dBm to -40.0 dBm range allowed in Envelope Delay Distortion measurements.

Press Softkey 4 (labeled "EXIT") when the sweep parameters have been set to the desired specifications. This returns the 930A to the main EDD selection display shown on the following page.



Again, once the 930A has been set up, it is not necessary to enter the set-up menu to start testing.

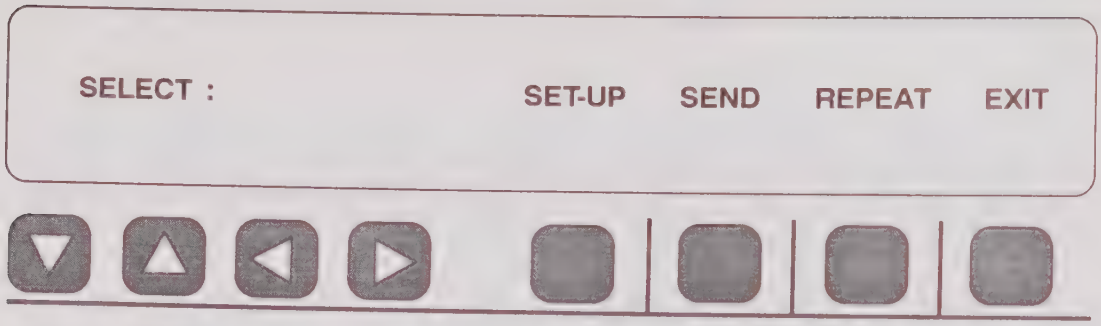
Envelope Delay Distortion is an end-to-end measurement with test sets located at each end of the trunk under test. Provided the test sets meet the requirements of AT&T Pub 41009 or IEEE Specification 743-1984 then it is not necessary to have the same manufacturers set at both ends for manual testing.

However, different manufacturers refer to the same tests by different names. **Return Reference mode** could be called the **Master** or **Send mode** while the **Repeat mode** may be referred to as **Re-Mod** or **Re-Modulating mode** or **Slave mode**. The 930A has two modes for simplicity: **SEND** and **REPEAT**. Forward Reference, Return Reference and Repeat mode testing can all be performed by the 930A.

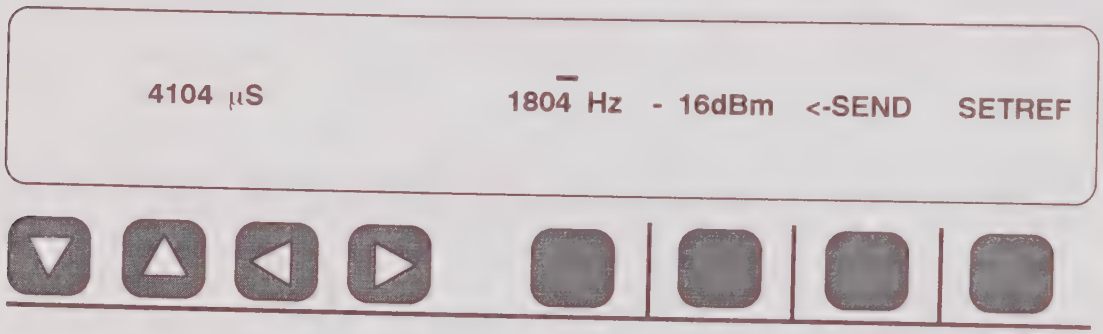
REMEMBER: One test set must be in the SEND or MASTER mode while the set at the other end must be in the REPEAT or SLAVE mode. Refer to the diagrams on page 4-194 for test set ups.

The following sections explain the operation of the 930A when performing EDD measurements.

4-12.2 EDD MEASUREMENT IN THE SEND MODE



Starting from the main EDD selection display shown above, press Softkey 2 (labeled "SEND") and a display similar to the following will appear:



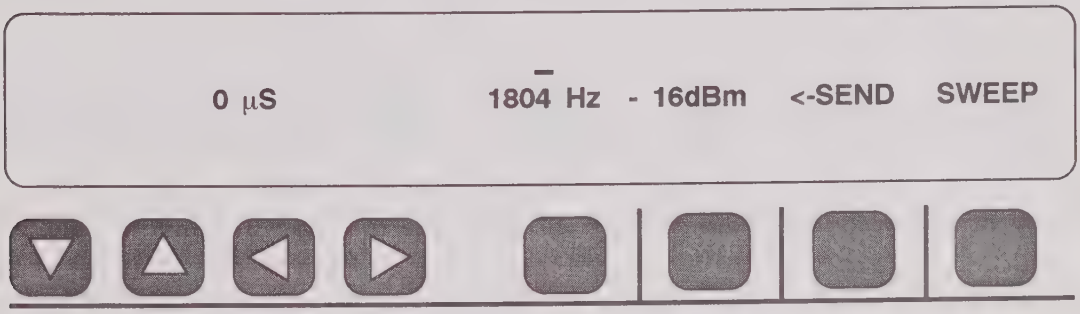
This display shows the calculated phase delay in microseconds for the return reference signal from the REPEAT or SLAVE unit and the level and frequency of the signal being sent from the SEND or MASTER unit. The usual reference (FORWARD or RETURN) signal is an 1804 Hz carrier at -16 dBm as shown above but it can be changed.

All measurements of EDD are made at the SEND or Master end of the circuit. EDD is also a referenced measurement and so the first thing the 930A does when it enters the SEND mode is to ask the operator to set the reference.

To change the reference frequency, press Softkey 1, under the frequency display. A highlighted cursor will appear over the last digit of the frequency (the "4" in this case) as shown above. Enter a new frequency using the numeric keypad. Press the **ENT** key or any Softkey to complete the entry. Only frequencies between 304 Hz and 3504 Hz are valid for this test.

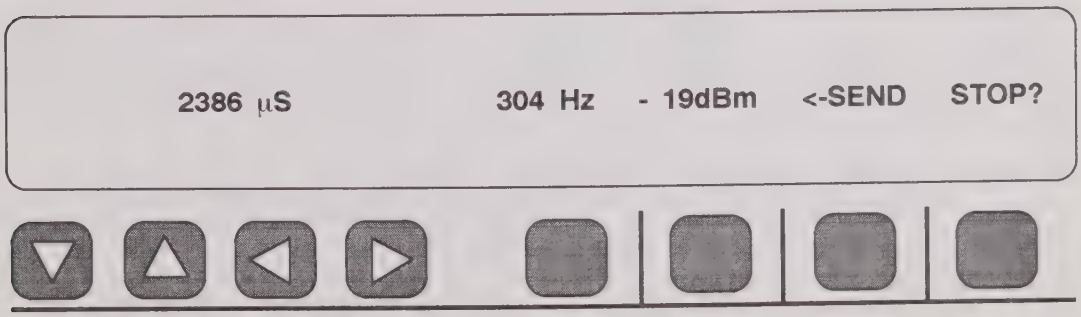
To change the level, press Softkey 2, under the level display. A highlighted cursor will appear over the last digit of the level. Enter a new level using the numeric keypad. Press the **ENT** or any Softkey to complete the entry. Only levels between 0 dBm and -40 dBm are valid for EDD measurements.

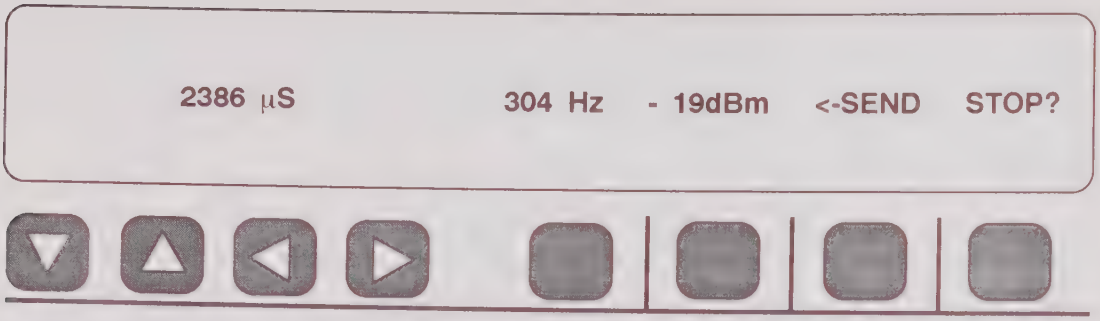
To set the reference delay, press Softkey 4 (labeled "SETREF") after allowing the delay reading to stabilize. The currently displayed envelope delay reading will become the reference and all subsequent measurements will be relative to this reference. This effectively "zeroes out" the current measurement. Again, the normal convention is to "zero" the delay measured at 1804 Hz. The display should resemble that shown below.



Once a reference has been established, the frequency or level of the outgoing reference signal can be changed or the frequency sweep can be generated. **To re-zero the reference without leaving the SEND mode**, press the **CLR** key. The current measurement will become the new zero reference.

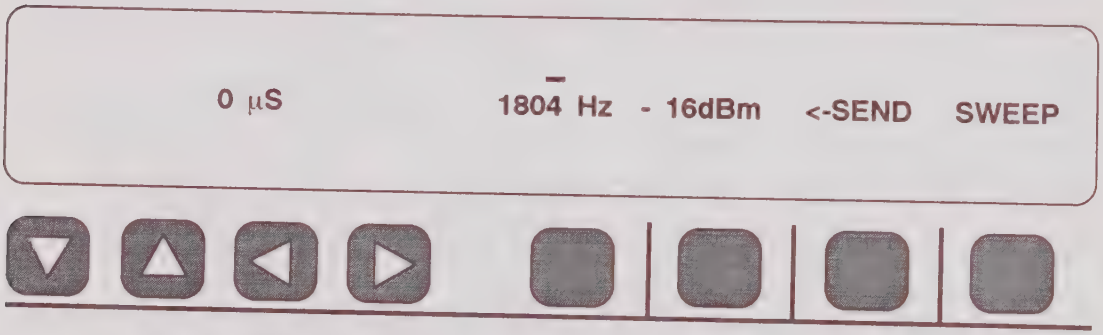
To send a sweep (and perform a Return Reference measurement) after setting the reference delay, press Softkey 4 (now labeled "SWEEP") from the display above. The 930A display will now resemble the display shown below:





The sweep parameters which were set up earlier will automatically begin. The delay will be measured and displayed for each frequency in the sweep. If a terminal or 80 column printer is attached and the 930A is in PRINTER remote mode (Requires option 930A-10C), the 930A will automatically print the delay at each frequency of the sweep (Refer to Section 5-2 for Printer set-up details). To interrupt the sweep without leaving the SEND mode, press Softkey 4 (now labeled STOP?) in the above display.

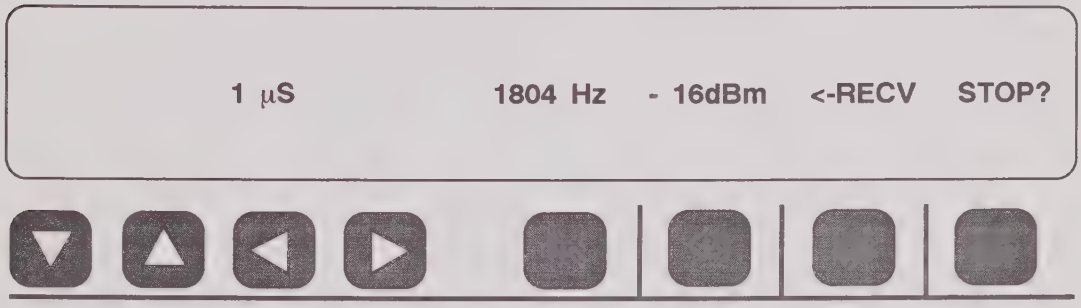
When the sweep completes or is interrupted, the 930A will revert to sending the reference frequency and Softkey 4 will again be labeled "SWEEP" as shown below:



The sweep can be repeated or the operator can manually set the frequency of the signal to examine the delay at frequencies of interest.

When all of the measurements are complete, the operator at the near or SEND end can alert the operator at the far end to sweep the return carrier. This will allow a **Forward Reference** measurement to be made of the delay of the return path while the SEND unit transmits the fixed reference signal toward the REPEAT or Slave unit at the far end.

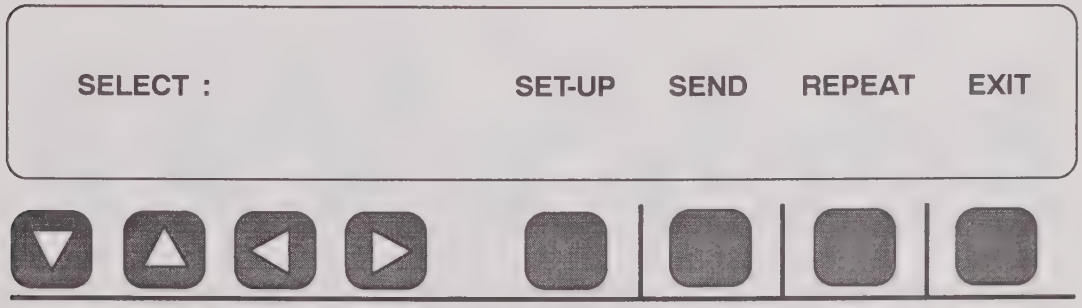
To examine the level and frequency of the returned carrier, press Softkey 3 (labeled "<-SEND"). The received level and frequency will be displayed and the label above Softkey 3 will change to read "<-RECV". The operator may toggle between viewing the outgoing signal or the returned carrier at any time. This is especially useful when the far end is sweeping the returned carrier. An example display of viewing the returned reference carrier while sweeping from the SEND unit is shown below:



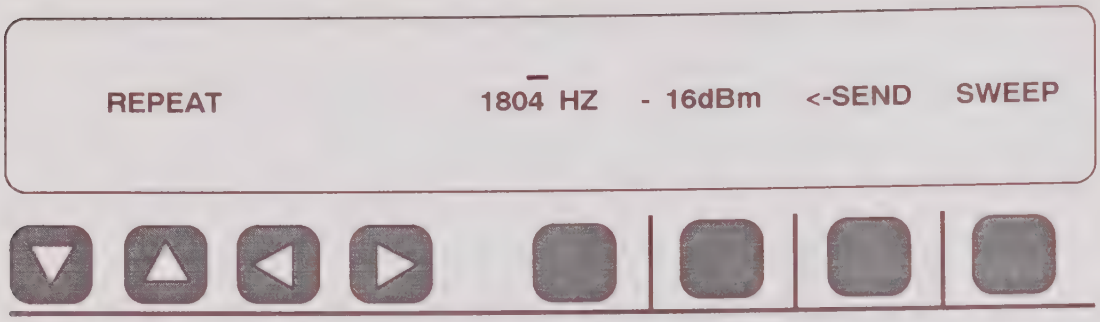
The carrier level should be within the 0 dBm to -40 dBm range and steady for the test to be valid.

4-12.3 REPEAT MODE OPERATION OF THE 930A

Once the near end 930A has been set up for the SEND mode the 930A at the other end of the circuit must be set to the REPEAT mode. The main EDD selection display is repeated below:



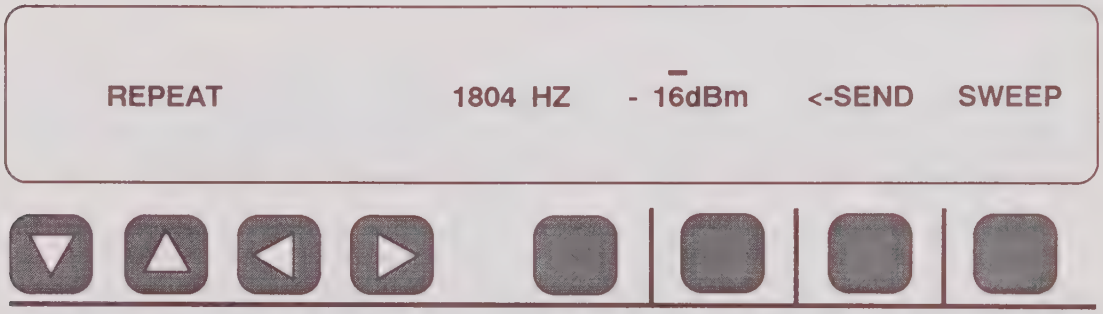
To place a 930A in the REPEAT or Slave mode, press Softkey 3 (labeled "REPEAT" above) and the display on the following page will appear.



This display shows the level and frequency of the carrier tone that is being used to return the amplitude modulation to the SEND unit. The default value is 1804 Hz at -16 dBm, as shown above.

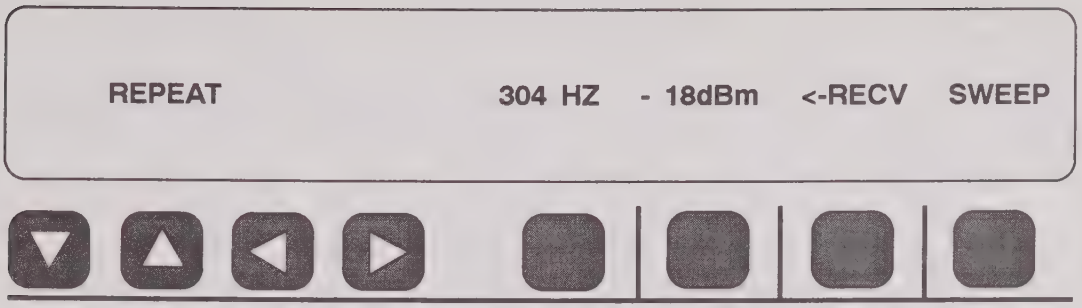
To change the frequency of the carrier, press Softkey 1, below the frequency display. A highlighted cursor will appear over the last digit of the frequency, as shown above. Use the numeric keypad to enter a new frequency if desired. Press the **ENT** key or any Softkey to complete the entry. Only frequencies from 304 Hz to 3504 Hz are valid carriers for this test.

To change the level of the carrier, press Softkey 2, below the level display. A highlighted cursor will appear over the last digit of the level, as shown below:



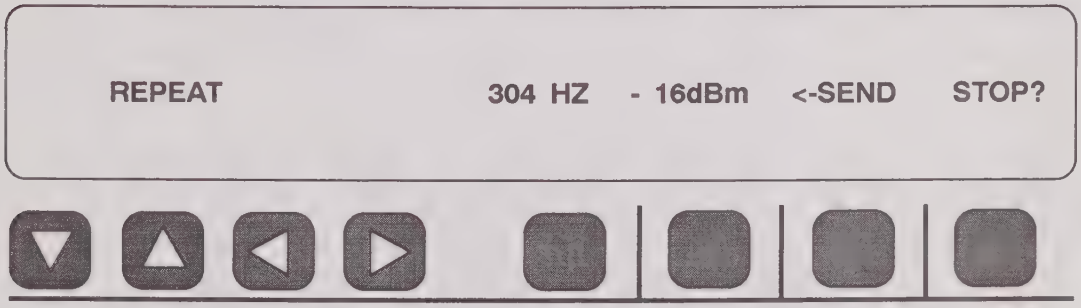
Use the numeric keypad to enter a new level. Press **ENT** or any Softkey to complete the entry. Only levels from 0 dBm to -40 dBm are valid for this test.

To examine the level and frequency of the signal being received, press Softkey 3 (labeled "<-SEND" above) and the display will change to that shown on the following page.



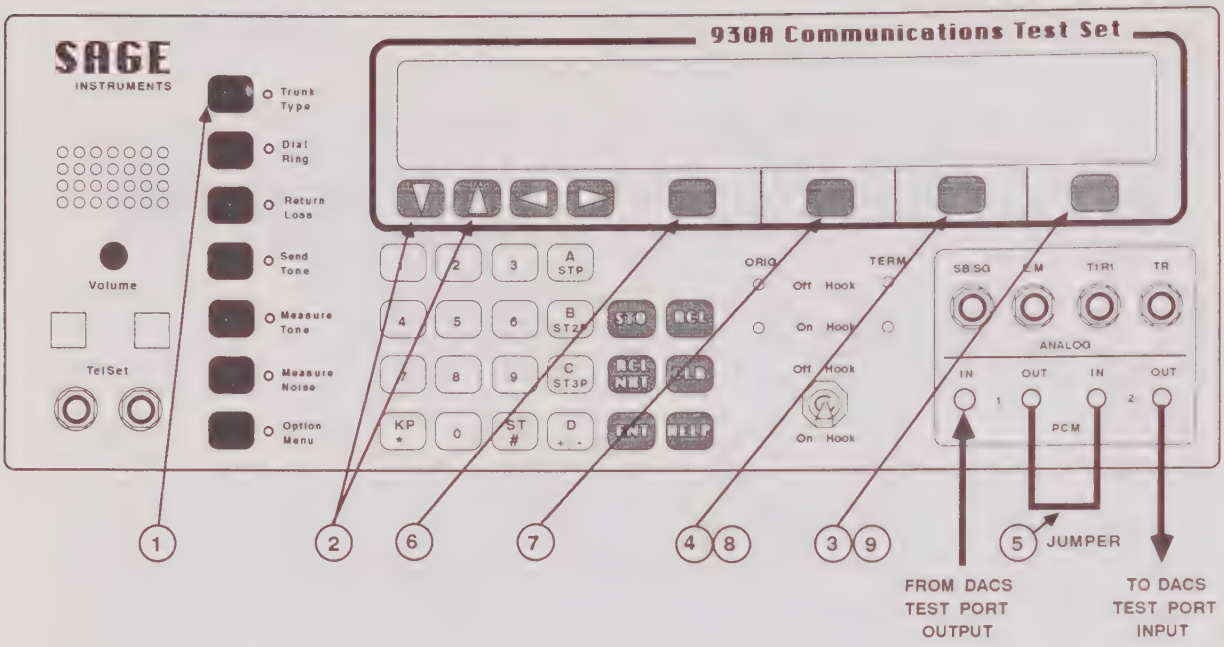
This shows the level and frequency of the signal being sent to the REPEAT unit from the SEND unit. The level must be between 0 dBm and -40 dBm for the test to be valid. Generally, this display would show a signal of 1804 Hz while the SEND end established a reference. This would be followed by a sweep generally from 304 Hz to 3204 Hz. When the sweep completes, the Return Reference part of the measurement is over and then it is the turn of the REPEAT unit to sweep for the **Forward Reference** test. The operator can toggle back and forth between seeing the signal received and the carrier being returned by pressing Softkey 3 (labeled "<-SEND" or "<-RECV").

To sweep the returned carrier for a Forward Reference measurement, press Softkey 4 (labeled "SWEEP" above) and the 930A display will change to:



The 930A will begin to sweep the returned carrier through the frequencies that were selected previously. To interrupt the sweep without leaving the REPEAT mode, press Softkey 4 (now labeled "STOP?"). When the sweep completes or is interrupted, the 930A will revert to sending the reference frequency and Softkey 4 will once again be labeled "SWEEP".

Press the OPTION MENU function key when testing is complete and the 930A will return to the main EDD selection display and the user may then EXIT by pressing Softkey 4 (labeled "EXIT").



To select the DCS/DACS® Trunk Type:

1. Press the Trunk Type Function key.
2. Use the UP/DOWN arrow keys or Softkey 1 to select "OPTIONAL TYPES:" display.
3. Press Softkey 4 labeled MORE.
4. Press Softkey 3 to select DACS® trunk type.
5. Connect Bantam male to Bantam male jumper cable from PCM OUT 1 to PCM IN 2.
6. Press Softkey 1 to select ODD or EVEN channel.
7. Press Softkey 2 to select SPLIT or MONITOR mode testing.
8. Press Softkey 3 to set states of A and B signaling bits.
9. Press Softkey 4 to print transmit and receive supervision status to 930A RS-232 serial interface.

DACS® INTERFACE CONNECTION
FIGURE 4-22

4-13 DCS/DACS® INTERFACE (OPTION 930A-24)

Installation of Option 930A-24 enables the 930A to be directly connected to the maintenance di-group at the Test Port of an AT&T Technologies Digital Access and Cross-Connect System (DACS®). This option was specifically designed to access the AT&T DACS® Test Port.

Not all Digital Cross-Connect Systems (DCS) are the same. Some provide ordinary T-1 test port access much like the DSX standard. This type of DCS does not require a special interface and can be tested using the standard 930A equipped with Option 930A-09.

IMPORTANT NOTE:

> Option 930A-24 is <u>not</u> required to test a DACS® or any DCS when connected to the T-1 span under test at the DSX jackfield. It is only required if the 930A is to be connected to the DACS® Test Port.

The AT&T DACS® provides test access in a peculiar format at it's Test Port and this requires the special interface of Option 930A-24. This will also be true of any other DCS which uses a Test Port with AT&T compatible test access format.

While the 930A can be operated manually in the DACS® mode, this software has been optimized for operation by remote control. It is particularly well suited to computer control or by human interface through a "smart" terminal capable of sending command strings to the 930A.

Normal T-1 PCM communications occurs over a 4-wire or full duplex circuit. That is, there are two digital bit streams: one outgoing and the other incoming. A PCM "channel" for two-way conversation is actually a synchronized time slice from two different bit streams. At the DSX-1 jackfield, access to both bit streams is necessary to monitor two-way communications, or to do drop-and-insert testing. A typical connection

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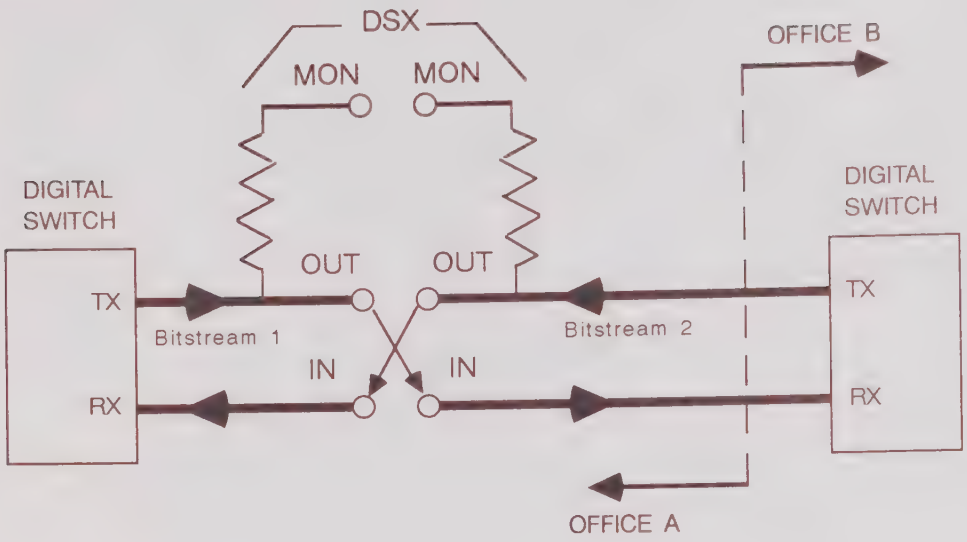
through a DSX is shown below:

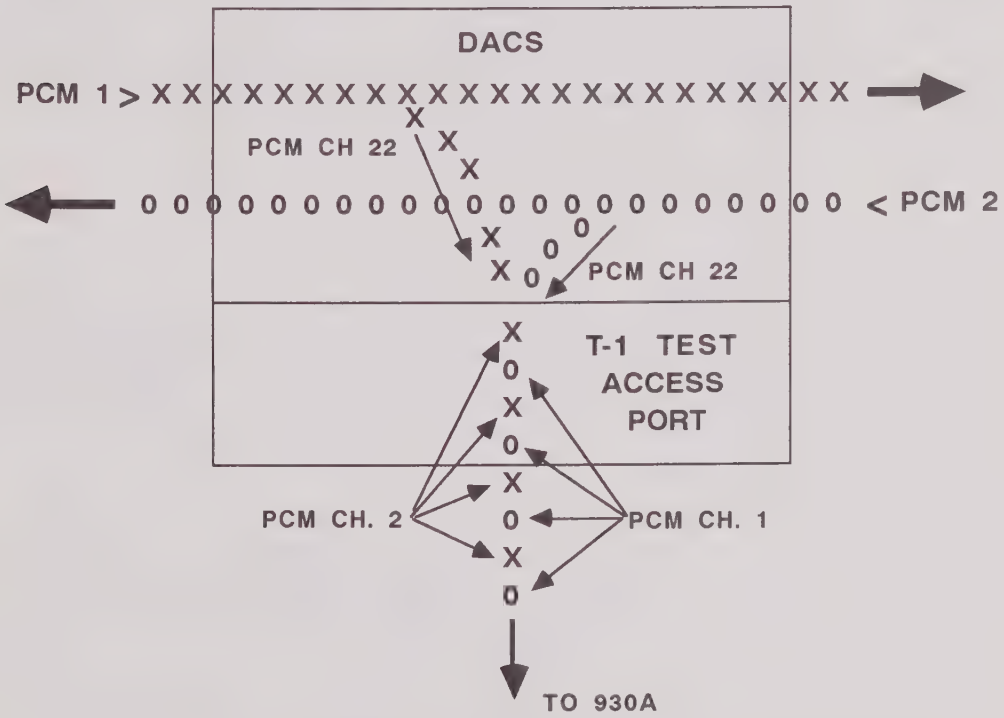


DSX AT POINT OF INTERFACE BETWEEN SWITCHES

Test access in the above diagram is provided by the DSX jacks for either direction of transmission and for monitoring either direction.

The AT&T DACS provides a somewhat different kind of test access from its built-in Test Port. Typically, many bit streams are passing through the DACS at once. The DACS can pick out any time slot (channel) from any bit stream and insert it into any time slot (channel) on any other bit stream. In short, it can perform electronic rearrangements on a "hitless" basis. The original DACS had the capacity to terminate up to 128 T-1 spans. In terms of through circuits however, this meant a maximum of 64 through T-1's. If two T-1's had to be tied up for testing access this would have meant a serious degradation in through cross-connect capacity. A rather ingenious solution to this problem enabled the use of one T-1 for test access by taking advantage of the DACS ability to electronically rearrange channels.

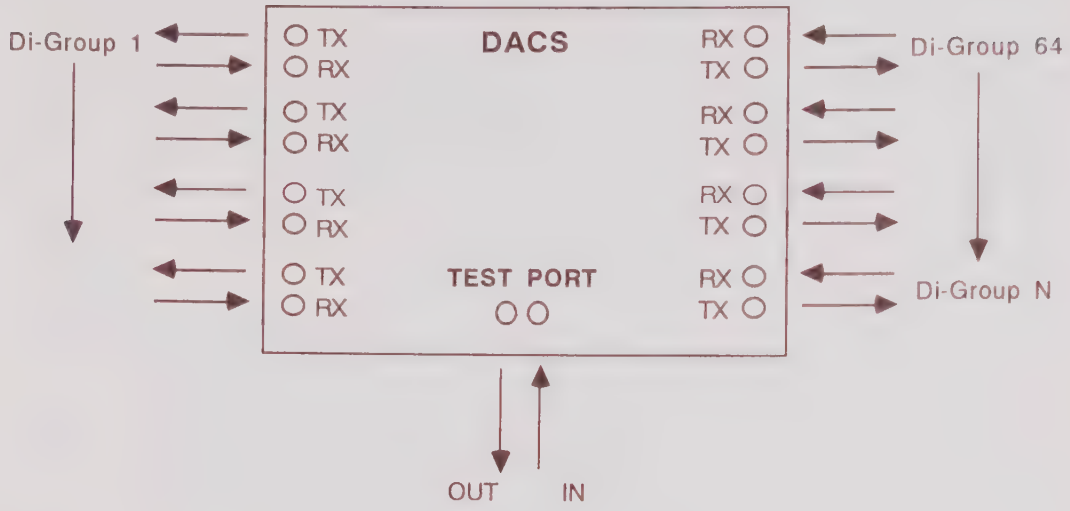
To allow remote automated testing of DACS frames from centralized locations (Digital STC's), each DACS has a Remote Port which enables a computer to control switching as well as test access, and a Test Port. The Test Port is where the single test di-group interfaces to the external test equipment. For testing purposes, the DACS pulls down the channel of interest from the incoming and outgoing bit streams and inserts them onto consecutive channels of the test di-group. A diagram of the process should prove helpful in explaining what goes on.



In this example, Channel 22 on a particular T-1 through DACS has been selected for testing. Channel 22 in direction 1 is brought down and placed on Channel 2 of the Test Di-Group while Channel 22 in direction 2 is brought down and placed on Channel 1 of the Test Di-Group. The fact that bi-directional Channel 22 has been placed on two adjacent channels on the Test Di-Group is what gave rise to the idea of ODD and EVEN channels. PCM Channels 1 and 2 were chosen for this example but they could as easily have been Channels 13 and 14 or 20 and 21.

In fact, with 24 channels available on the Test Di-Group, it is possible to map up to twelve working channels onto the test port for testing at any one time.

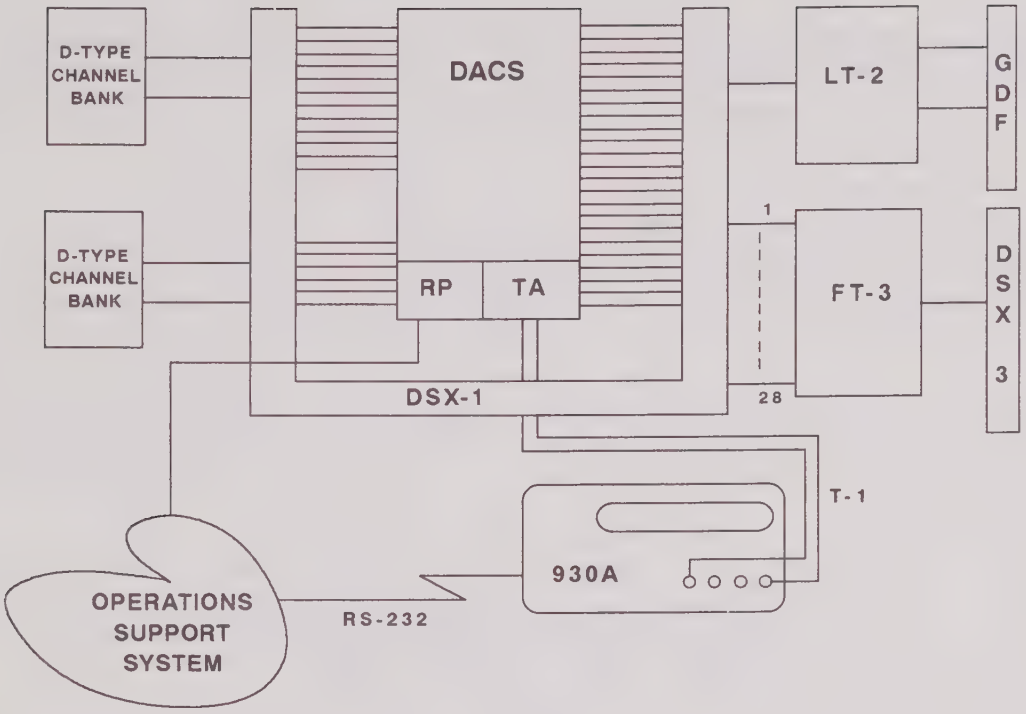
A picture of the external connections to the DACS follows:



Di-Groups 1 through N pass through the DACS and are in turn connected to a DSX jackfield which in effect surrounds the DACS. The jackfield provides a convenient demarcation point for record keeping as well as allowing conventional test access. Test equipment capable of dealing with the Test Port's non-standard format can be connected directly to the test port instead.

So, the difference is that testing at the DSX involves testing on the same channel on two different bit streams, while testing at the AT&T DACS Test Port involves testing on two different channels on the same bit stream. The Model 930A when equipped with Option 930A-09 can perform ordinary Drop-and-Insert testing at the DSX. However, when the 930A is equipped with Option 930A-24 in addition to Option 930A-09, then it can test at the DSX or at the Test Port of DACS. With Option 930A-24, the Model 930A can perform its full range of signaling and trunk transmission tests over the DACS Test Port. If desired, up to twelve 930A's can be daisy-chained onto a single DACS test port for simultaneous testing of multiple di-groups or the 930A can be freely intermixed with other manufacturers DACS test sets.

An overall picture of a typical DACS installation in the special services environment is shown on the following page.



The diagram above shows a DACS providing interconnections between various pieces of Central Office equipment as well as providing test access for a Model 930A. In this example the Operations Support System controls both the DACS and the 930A and also serves as the data base for test results.

In addition to the 930A's usual capabilities, Option 930A-24 also enables:

1. Monitoring or testing any channel pair (01/02 to 23/24)
2. Monitoring or testing on the ODD or EVEN channel.
3. Sending any combination of "A" and "B" bits on the two channels.
4. Remote printing of transmit and receive supervision on both channels.

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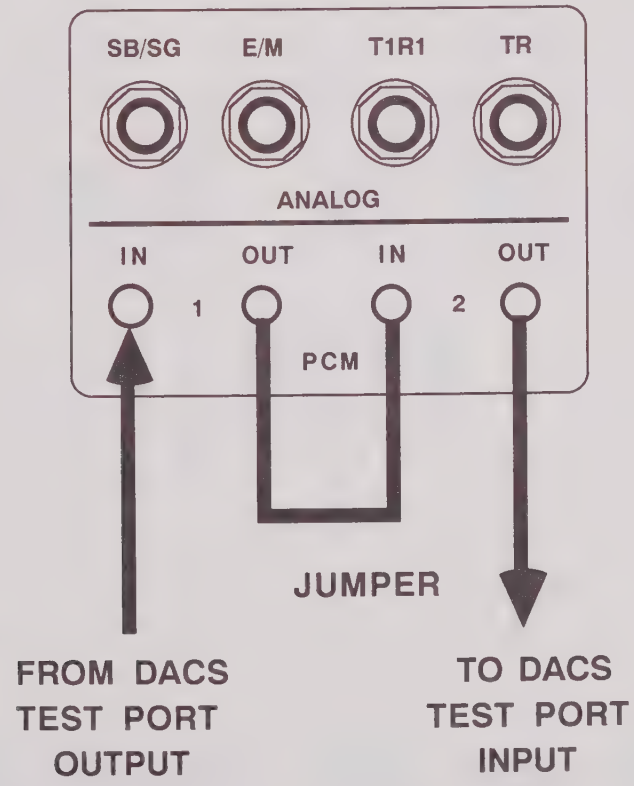
4-13.1 TEST CORD CONNECTIONS IN THE DACS® TRUNK TYPE

Prior to setting up the 930A for the DACS® mode of operation it is a good idea to examine the difference in test cord connection between this mode and ordinary T-1 test access at the DSX.

The two PCM circuit boards within the 930A which comprise option 930A-09 usually operate independently. However, in the DACS® mode, it is necessary to have them operate in series so that one can operate on one channel of the T-1 passing through them while the other operates on the adjacent channel.

A diagram of a 930A front panel configurator is shown below with a jumper cable connected to accomplish the necessary series connection of the 930A PCM circuit boards.



A short test cord connected between the PCM OUT 1 and PCM IN 2 jacks places the internal PCM circuit boards in series and then the 930A can be connected to the DACS® Test Port as shown using PCM IN 1 and PCM OUT 2.

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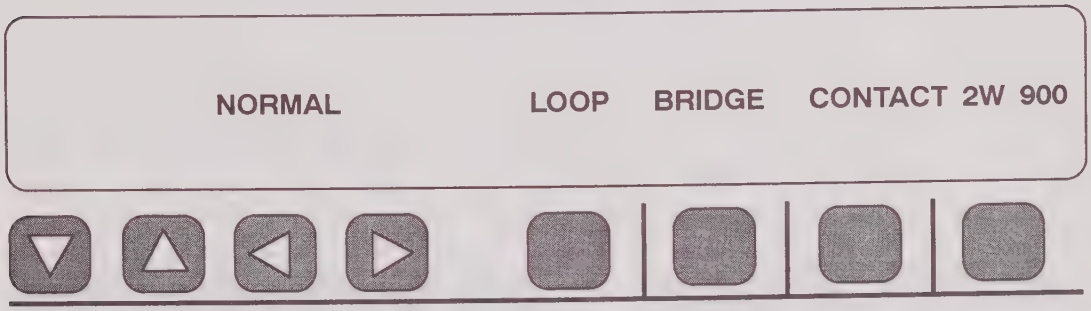
4-13.2 FRONT PANEL KEY FUNCTIONS IN DACS® TRUNK TYPE

In order to interface the Model 930A to the Test Port on an AT&T DACS®, the 930A must have Option 930A-24 installed. Once this option has been installed, the operator can select the "DACS" trunk type from the Trunk Type function. The following procedure outlines the steps necessary to set up the 930A.

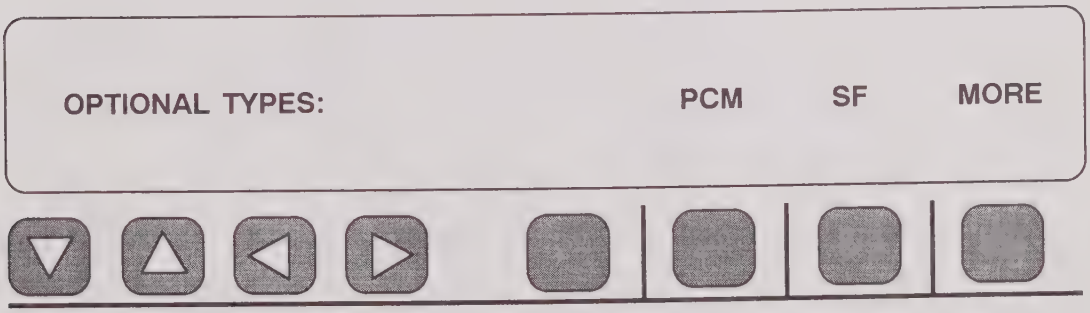
Press the Trunk Type Trunk Type function key

For example purposes, suppose that the current trunk type selected is displayed as follows:

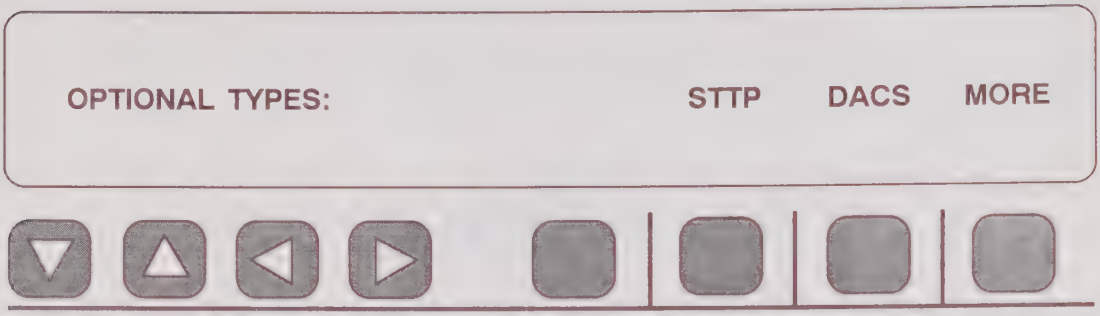


Use the UP/DOWN arrow keys

or Softkey 1 to scroll through the trunk types until the "OPTIONAL TYPES" is displayed as shown below:



Press Softkey 4 labeled "MORE" and the next display of trunk type options will be:

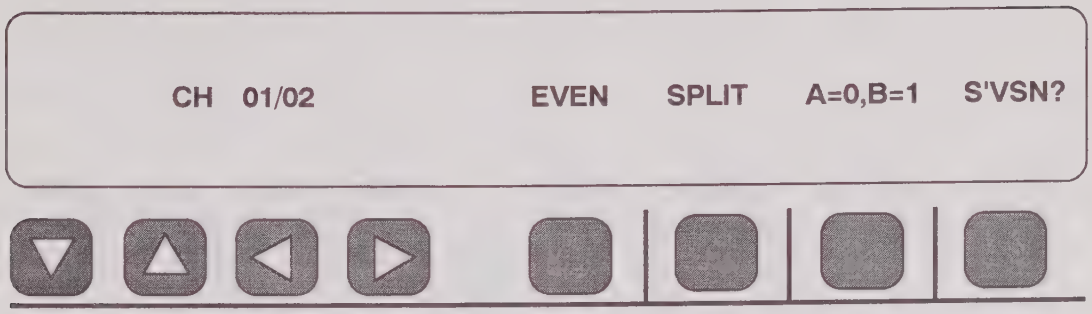


Press Softkey 3 labeled "DACS" and the main DACS trunk type menu will be displayed as:

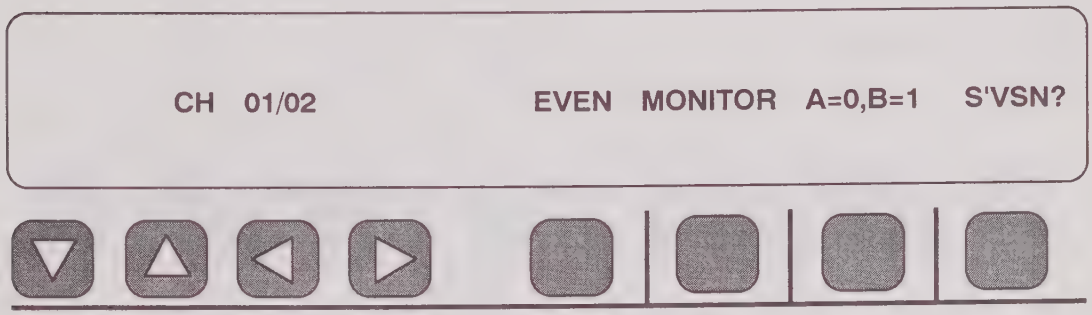
This display shows that the current channel pair under test is 01/02, testing is on the Odd channel, the set is in the SPLIT (Drop-and-Insert) mode and the state of the transmitted supervision bits on the channel under test is A=1 and B=0.

The channel pair can be changed either numerically, from the keypad or over the remote port by entering "0 through 9" as appropriate, or by using the front panel UP/Down arrow keys or remote "^J" and "^K", similar to changing channels in ordinary PCM testing.

Pressing Softkey 1 (Remote "J") toggles between testing on the Odd or Even channel.



Pressing Softkey 2 (Remote "K") toggles between MONITOR and SPLIT (Drop-and-Insert) mode testing.

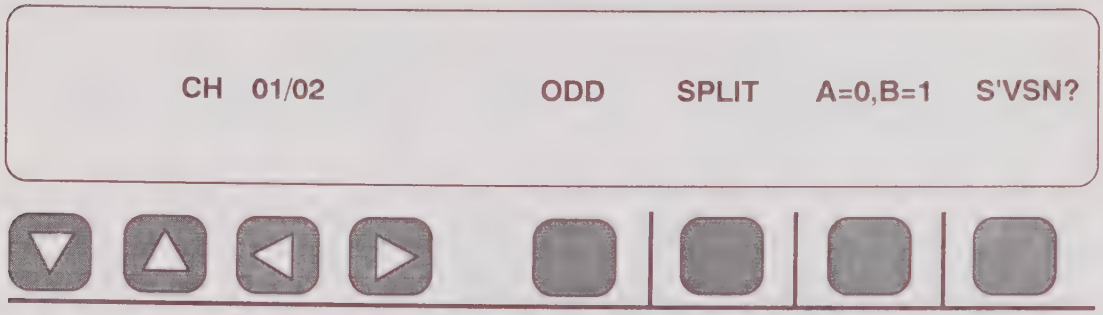


Pressing Softkey 4 (Remote ";") causes the 930A to print transmit and receive supervision for both channels to the serial port. The format is:

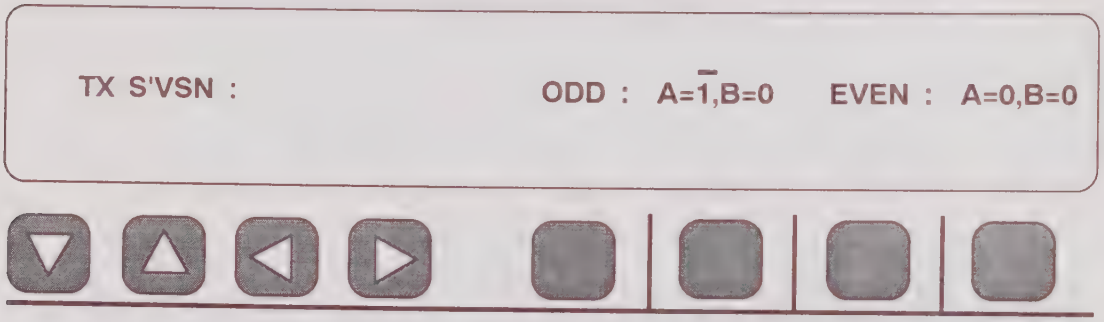
SUPERVISION	TRANSMIT	RECEIVE
ODD:	A=0,B=1	A=1,B=1
EVEN:	A=0,B=0	A=1,B=1

If the 930A is in MONITOR mode, supervision is not sent over the PCM bit stream.

To change the transmitted supervision states, begin back at the SPLIT mode display repeated below:



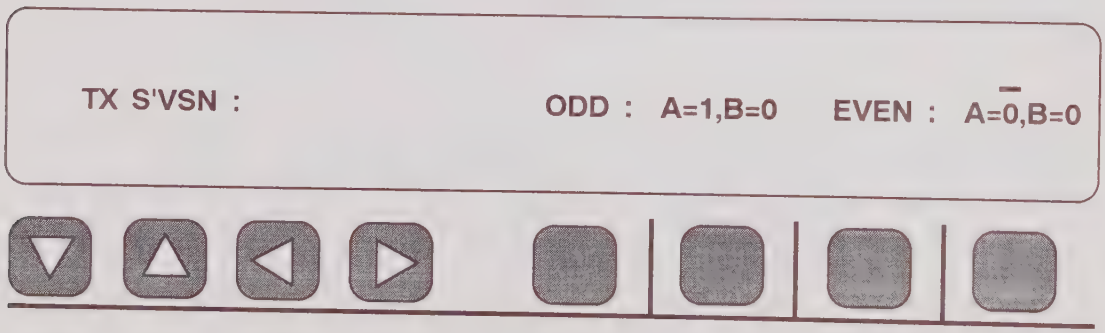
Press Softkey 3 (Remote "L") and the following display will appear:



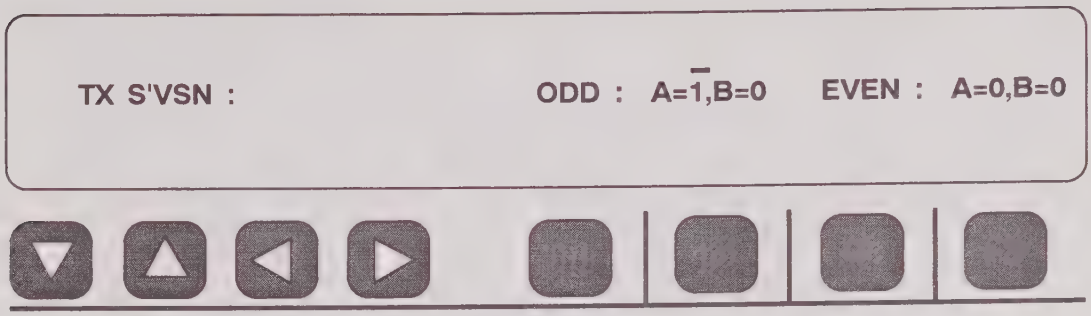
The cursor will appear over the A bit on the ODD channel. Entering a "0" or a "1" will set the bit and advance the cursor to the B bit. The cursor advances after each bit is set.

Pressing Softkey 1, Softkey 2 or the Left arrow key (Remote "^H") will position the cursor over the ODD A bit.

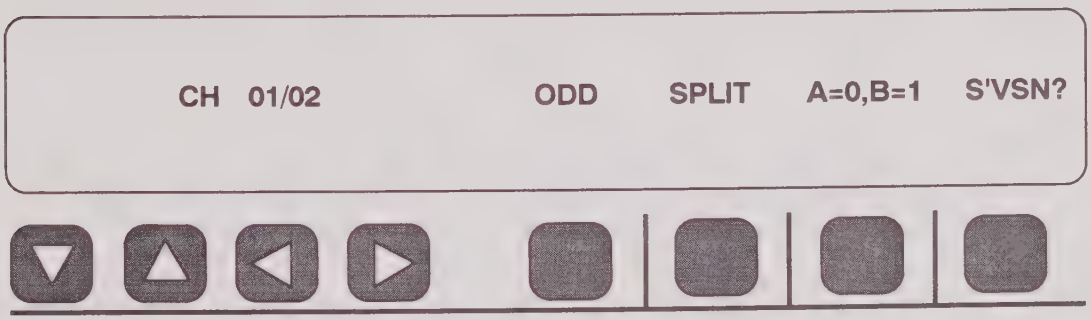
Pressing Softkey 3, Softkey 4 or the Right arrow key (Remote "^L") will position the cursor over the EVEN A bit as shown:



After setting the EVEN B bit, the cursor returns over the ODD A bit.



Pressing the ENTER (Remote Carriage Return "<CR>") key or the Trunk Type function key returns the display to the main DACS menu:



4-13.3 PROGRAMMING THE 930A IN DCS/DACS MODE

Since Option 930A-24 was optimized for operation from a remotely located Terminal or Computer, this section is provided to give the operator some information and sample ASCII command test strings. A general overview of Computer and Terminal remote control can be found in Section 5 of this manual.

Since the 930A may exist side by side with other test equipment, it may be desirable to have a generic set of commands available to the testers, which are then translated by the computer into command strings for the current test set (either a 930A or other test set), in a manner transparent to the user.

A few sample command strings are listed below:

DESIRED ACTION	ASCII STRING*
Go to MONITOR mode. Monitor ODD channel.	"A?KK<CR>"
Go to MONITOR mode. Monitor EVEN channel.	"A?;K<CR>"
Go to SPLIT mode. Test ODD channel.	"A?K;<CR>"
Go to SPLIT mode. Test EVEN channel.	"A?;;<CR>"
Toggle between EVEN and ODD channel.	"AJ"
Toggle between SPLIT and MONITOR mode.	"AK"
Send A=0 B=0 on ODD channel.	"AL00<CR>"
Send A=1 B=1 on EVEN channel.	"ALL11<CR>"
Send A=0 B=1 on ODD channel and A=1 B=0 on EVEN channel.	"AL0110<CR>"
Relay supervision information to tester.	"A;"
Go to SPLIT mode. Test on EVEN channel. Send FXO idle on ODD channel and FXS ground start (seizure) on EVEN channel.	"A?;;1100<CR>"
Send Loopback (2713 Hz) at -13.0 dBm.	"D?K2713<CR>130<CR>
Send 1004 Hz at 0 dBm.	"D?K1004<CR>0<CR>
Toggle Tone ON and OFF.	"D;"
Set frequency to 404 Hz.	"DJ404<CR>"
Set amplitude to -10.0 dBm.	"DL100<CR>"
Go to Measure Tone. Get two measurements.	"EZZ"
Go to Measure Noise. Get two measurements.	"FZZ"
Select DTMF outpulsing.	"B?;"
Select MF outpulsing.	"B?L"
Select DP outpulsing.	"B?K"
Dial 9. Pause. Dial 1 408 761 1000.	"Bo 9-14087611000OK"

* The ASCII strings are enclosed in quotes. Do not send the quotes to the 930A. The carriage return is denoted by "<CR>". Blanks are significant characters (the ASCII space character is the CLEAR command). The 930A is sensitive to upper and lower case.

SECTION V
REMOTE CONTROL OPERATION

5-1 INTRODUCTION

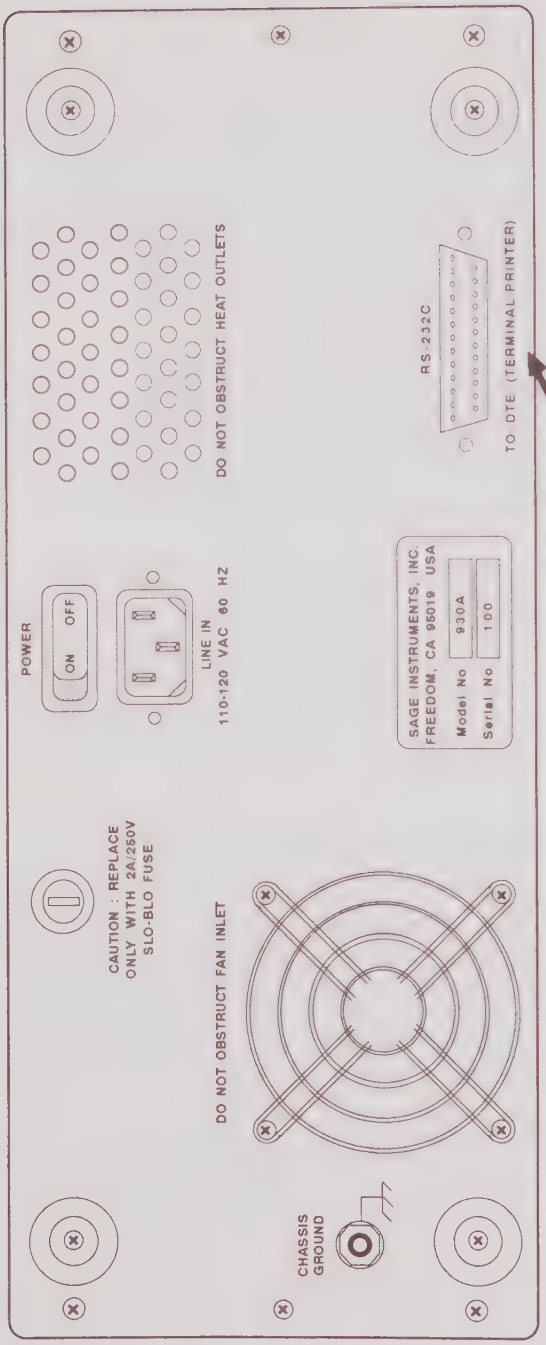
The Model 930A, when equipped with Option 930A-10C or -11, may be remotely controlled, or may itself control a printer, through an RS-232C serial port located on the rear panel. The connector is a standard female 25 pin miniature "D" type connector. The mating male connector should be an Amphenol type 206771-1 or equivalent. Refer to Figure 5-1 for the location of the serial port on the rear panel.

The Model 930A has been designed to make operation under remote control as much like manual control as possible. There are no opcodes to memorize. Each front panel key function can be activated by a single ASCII character (a keystroke on the terminal or computer keyboard).

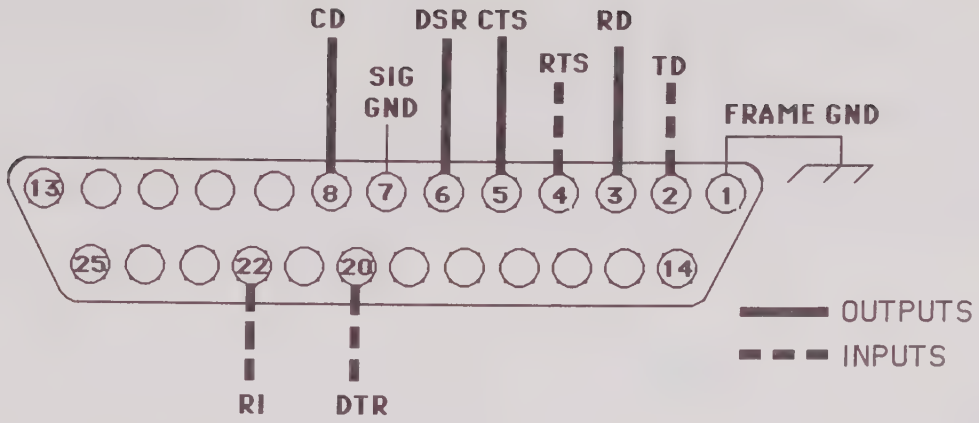
The Model 930A will work with most printers and terminals without modification to cables or reconfiguration of pins. The Model 930A serial interface is configured as Data Communication Equipment (DCE) and wants to "see" Data Terminal Equipment (DTE) connected to it. Since it is emulating a Modem (DCE), most terminals (DTE) can be cabled directly to the Model 930A remote port.

If a computer is being used to control the Model 930A and it has the capability of being either a DTE or a DCE, make sure that it is set to DTE emulation before connecting it to the Model 930A. If the equipment cannot be configured as DTE, then it will be necessary to swap pins 2 and 3 (Transmit and Receive Data). This can be accomplished by using a special cable known as a "NULL MODEM" or a breakout box. The pinouts for the Model 930A connector are shown in Figure 5-2.

Both Options 930A-10C and -11 provide Real Time Clock. The set-up of the Time/Date clock is described in Section 5-1.3.



RS-232C CONNECTOR LOCATION
FIGURE 5-1



PIN	TO DTE	TO DCE	NAME	FUNCTION
1			FG	FRAME GROUND
2		→	TD	TRANSMITTED DATA
3	←		RD	RECEIVED DATA
4		→	RTS	REQUEST TO SEND
5	←		CTS	CLEAR TO SEND
6	←		DSR	DATA SET READY
7			SG	SIGNAL GROUND
8	←		DCD	DATA CARRIER DETECT
20		→	DTR	DATA TERMINAL READY
22	←		RI	RING INDICATOR

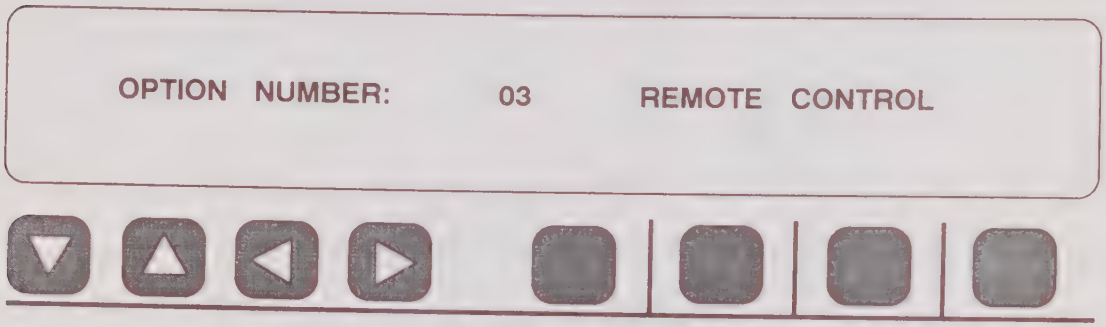
RS-232C CONNECTOR PINOUTS

FIGURE 5-2

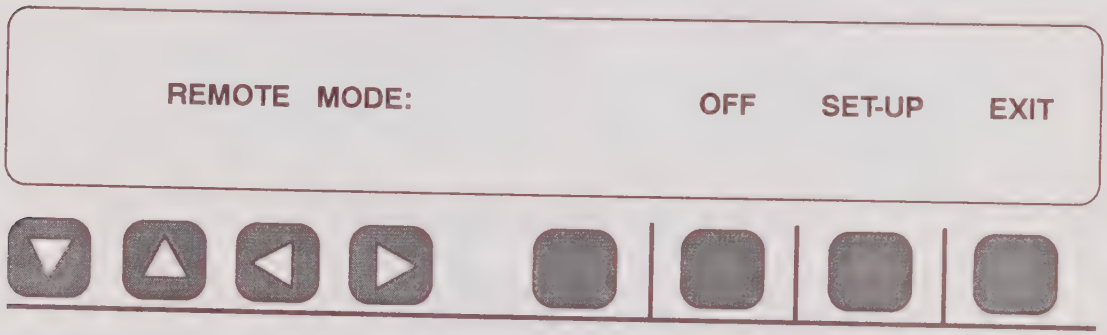
The remaining 15 pins are not connected. Applying a voltage to pins 1 or 7 will cause damage to the 930A. The pinouts shown in Figure 5-2 connect directly to a DTE (Terminal) or printer. For connection to a DCE, a "NULL MODEM" connection, as previously described, must be used.

5-1.1 MODE SELECTION

Once Option 930A-10 or 11 has been installed in the 930A, any of the Remote Control modes, including Printer mode, may be selected. To select any of the remote modes press the OPTION MENU key and use the UP/DOWN Arrow keys to go to Option Menu 3. The display will appear as:



Pressing any Softkey will allow the user to enter the option and the display will look like:



If a Remote mode has already been selected, then the current mode will be displayed instead of the word "OFF". Pressing Softkey 2 (labeled "OFF" in the illustration above) selects the Remote Mode. The modes available with Option 930A-10 RS-232C Remote are:

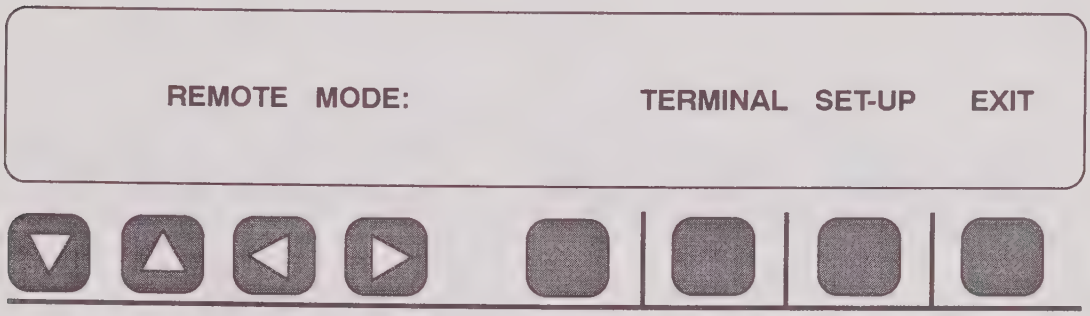
"OFF" ---------- Manual control
"TERMINAL" ------ For use with dumb terminals
"COMPUTER" ------ For use under computer control
"PRINTER" -------- Used to drive any serial printer connected to the RS-232 serial port.

Other modes which may be displayed, such as MASTER/SLAVE, are intended for use with a built-in Modem (Option 930A-11) or are custom remote modes for a particular customer. Selecting one of these modes will have no

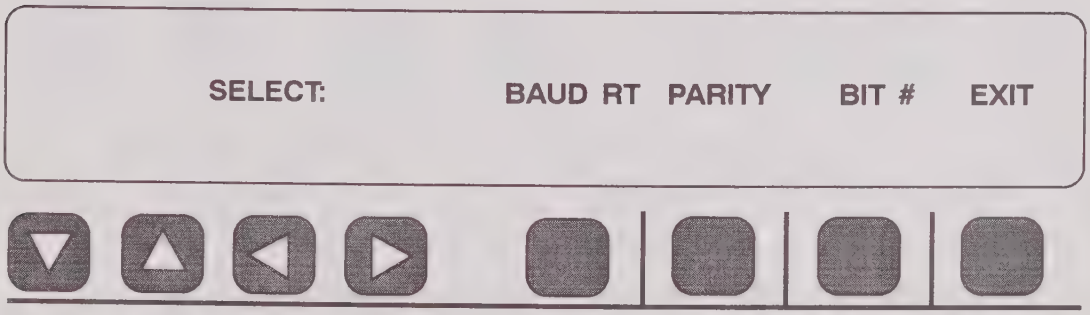
effect if they have not been installed in the unit. Press Softkey 2 until the desired mode appears. Then press Softkey 4 (labeled "EXIT") and the currently displayed mode will be initialized. Make sure that the current mode is "OFF" if it is desired to operate the 930A in the manual mode. Once the user has selected the correct remote mode, either "TERMINAL", "COMPUTER" or "PRINTER", then it is necessary to set up the 930A's interface to match the equipment connected to it. This procedure is described in the next sub-section.

5-1.2 INTERFACE FORMAT SET-UP

When inside Menu Option 3 (REMOTE CONTROL), Softkey 3 is labeled "SET-UP" as shown in the example below:



Pressing Softkey 3 will bring up the set-up menu as shown below:



This "SET-UP" menu is used to examine or adjust the data format of the 930A's asynchronous RS-232C serial interface. This menu enables the user to adjust the baud rate, parity, and number of data bits to match the data format of any Terminal, Computer or Printer which is connected to the 930A. The settings are retained in non-volatile memory and once adjusted need not be changed or examined unless a new item of equipment is to be connected to the 930A. Pressing Softkey 4 exits the menu.

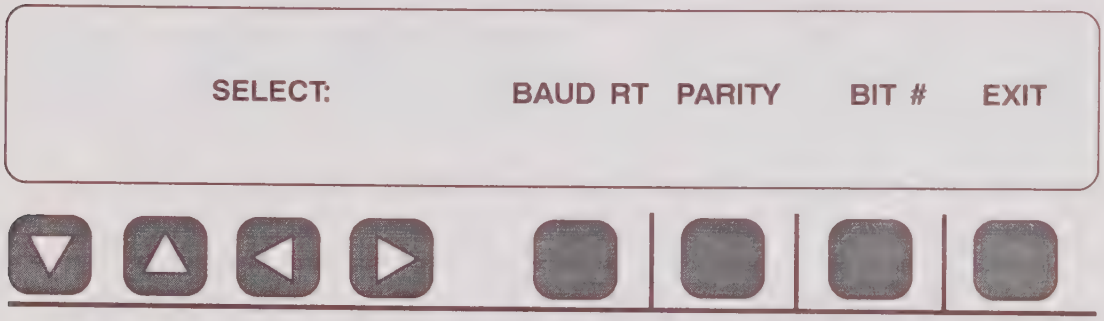
NOTE:

The 930A is factory preset to a data format of 9600 baud, even parity, seven data bits and one stop bit. The 930A will return to this default condition if a "Cold Boot" is performed. Otherwise, the 930A will retain any new settings which the user enters, even when power is turned off, until they are changed by the user.

The following step by step procedure illustrates the set-up of the data format and is applicable to any of the modes.

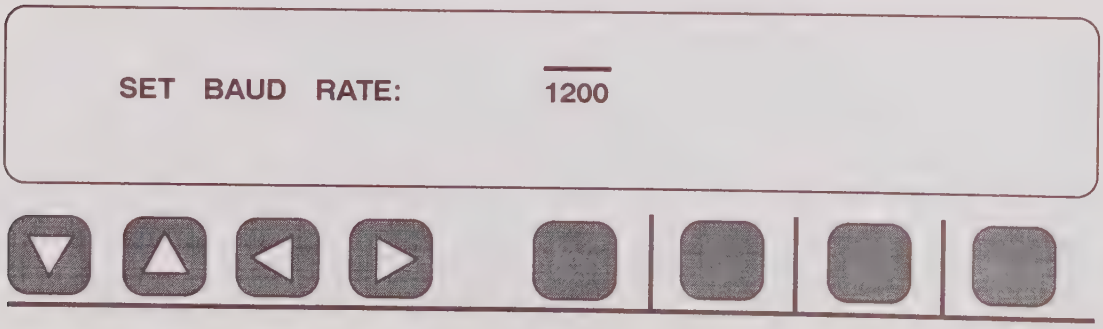
EXAMPLE:

For this example, it is given that the user has gone to Option Menu 3. entered it and pressed Softkey 3 (SET-UP). The display at this point looks like:



With this initial display, the step by step procedures follow as outlined below.

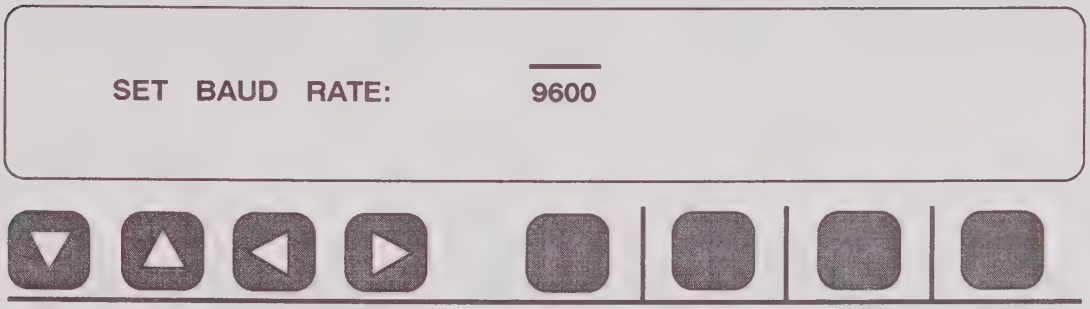
BAUD RATE: To examine or adjust Baud Rate press Softkey 1. The display will appear somewhat like the one shown below (the rate may differ):



In this example, a value of 1200 baud is used. If this were the desired value, then pressing the ENT (Enter) key or any Softkey would cause this rate to be initialized. If another rate is desired the user can type in the new baud rate using the numeric keypad. Assume that it is desired to operate at 9600 baud. In this case, after Softkey 1 had been pressed, the following sequence of events would be performed using the Numeric keypad:

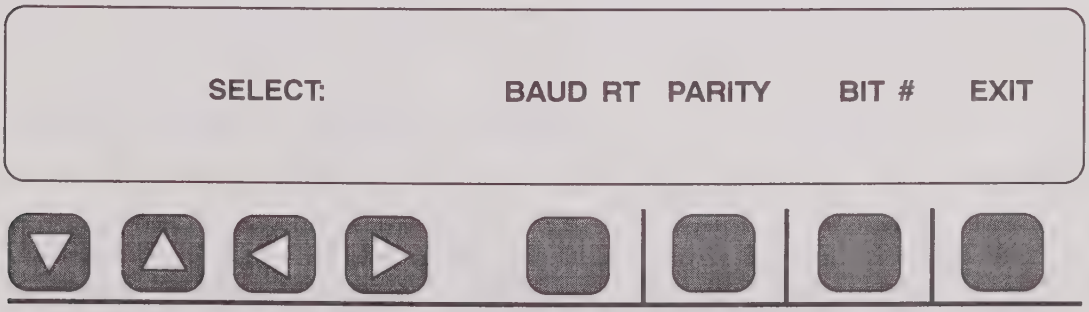
Press [9] then [6] then [0] then [0]

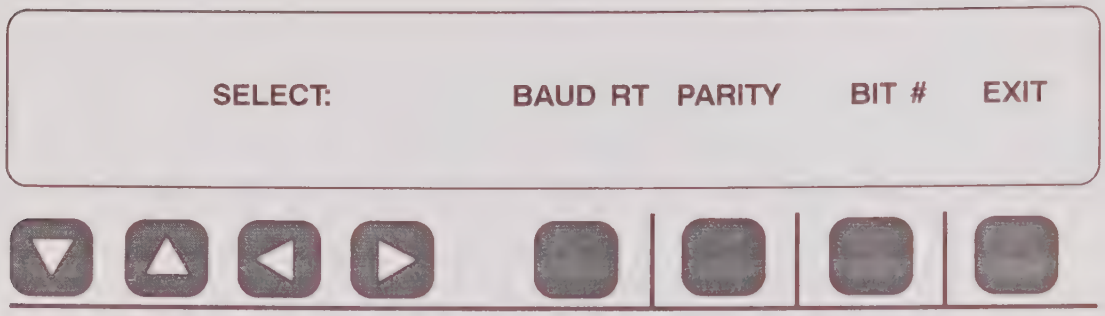
The display of the 930A would then be:



Press [ENT] to enter the rate and return to the Set-Up Menu.

The 930A Set-Up display reappears and the user may now examine or adjust one of the other parameters such as parity. The 930A serial interface supports any baud rate between 110 baud and 9600 baud. The most commonly used baud rates within this range are: 110, 134.5, 150, 200, 300, 600, 1200, 2400, 4800, 7200, and 9600. It is recommended that whenever possible, the operator should use 9600 baud so as to minimize transmission lag.





PARITY: To examine or adjust the parity, press Softkey 2 when in the Set-Up menu (shown above) and the following display will appear:

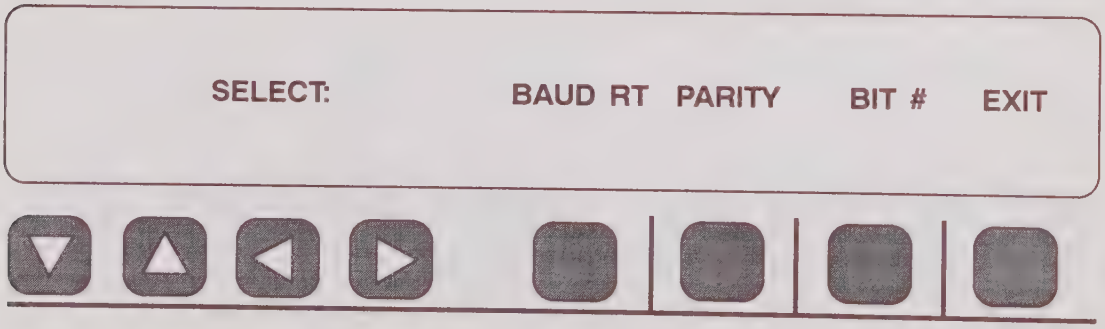
The current parity state will be highlighted (EVEN in this example).

Press Softkey 2 (labeled "OFF") for No Parity

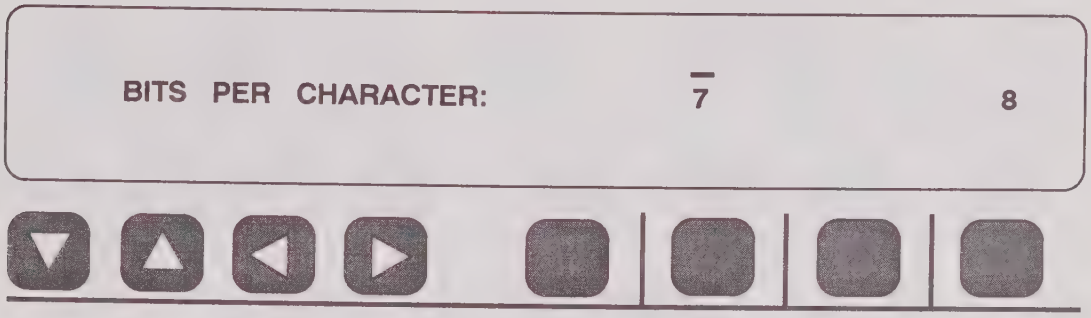
Press Softkey 3 (labeled "EVEN") for Even Parity

Press Softkey 4 (labeled "ODD") for Odd parity

Once the user has pressed the appropriate Softkey, the 930A will immediately initialize that choice and revert to the Set-Up menu for further selections.



DATA FORMAT: The 930A supports ASCII data formats of 7 or 8 bits length and 1, 1-1/2 or 2 Stop bits. To examine or change the currently selected data format, press Softkey 3 when in the Set-Up menu (labeled BIT #) and the following display will appear:



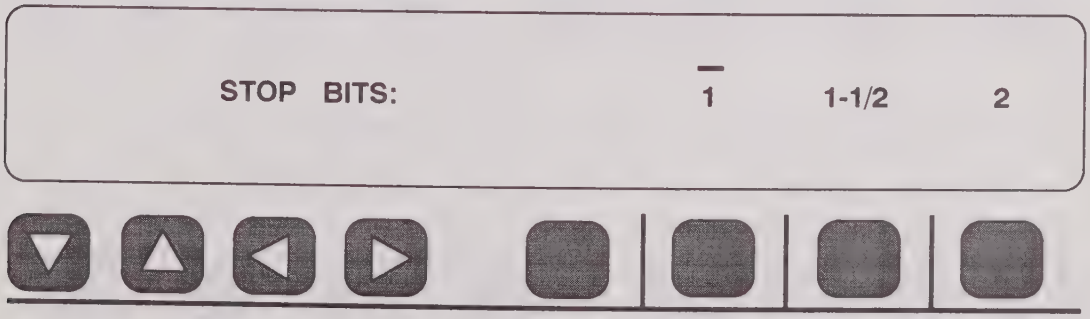
The currently selected number of data bits will be highlighted ("7" in this example).

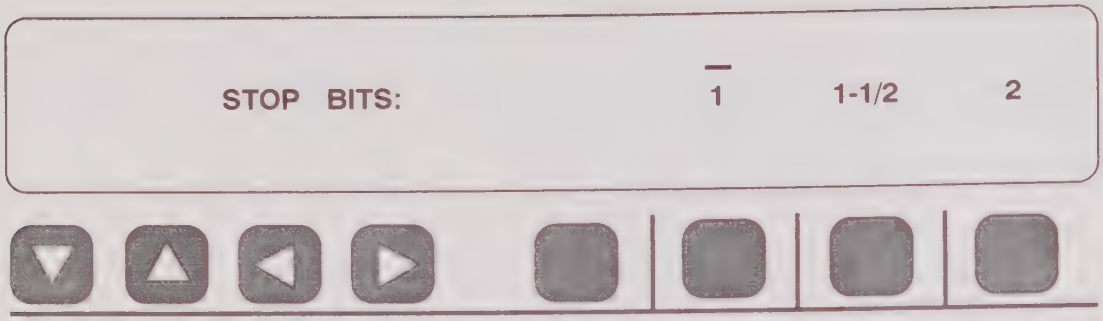
Press Softkey 2 (labeled "7") to select 7 bit ASCII code.
Press Softkey 4 (labeled "8") to select 8 bit ASCII code.

NOTE

"Highlighted" characters (those with a cursor above them in the 930A's display) are sent with bit eight (MSB) set. Some printers and terminals treat characters with bit eight (8) set as graphics characters. Therefore, we recommend seven (7) data bit length for use with printers and terminals.

Once the user has selected the appropriate ASCII word length, the display will advance to read:





The currently selected number of stop bits will be highlighted ("1" in this example).

Press Softkey 2 (labeled "1") to select 1 Stop bit.
Press Softkey 3 (labeled "1-1/2") to select 1-1/2 Stop bits.
Press Softkey 4 (labeled "2") to select 2 Stop bits.

The 930A will automatically return to the Set-Up menu once the user has pressed the appropriate Softkey.

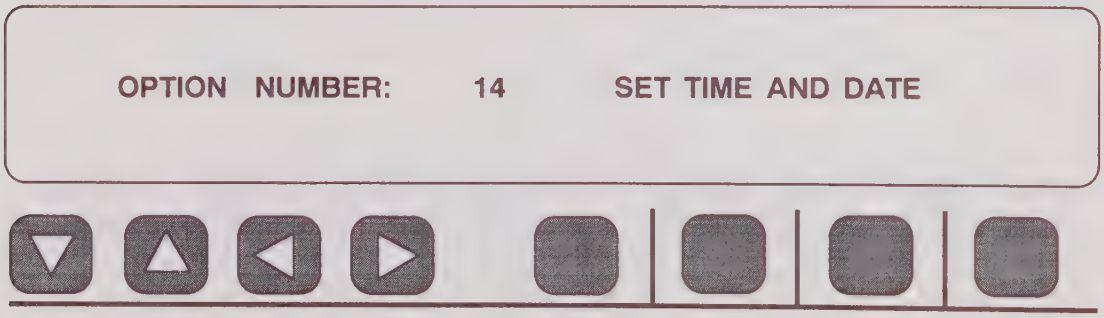
5-1.3 TIME AND DATE SET-UP PROCEDURE

In order to set the Time and Date function it is necessary to perform the following steps:

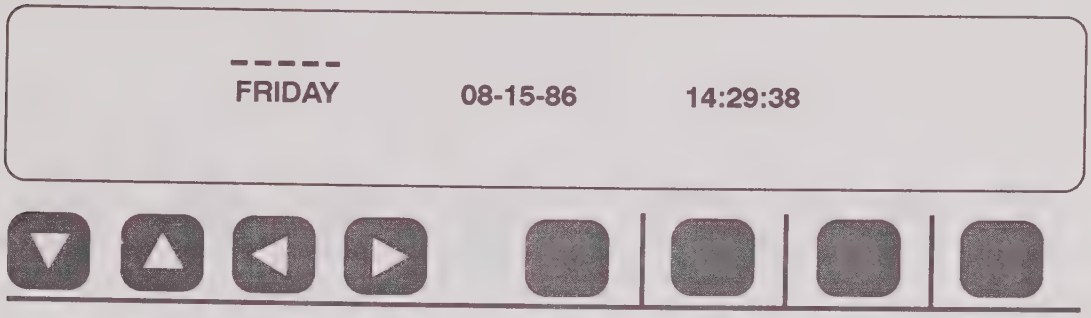
Press the OPTION MENU Option Menu function key.

Use the UP/DOWN arrow keys to select Menu Option 14, SET TIME AND DATE.

The 930A display will appear as:



Press any Softkey to enter the menu option and the 930A display will show the currently stored time and date as in the example display which follows:



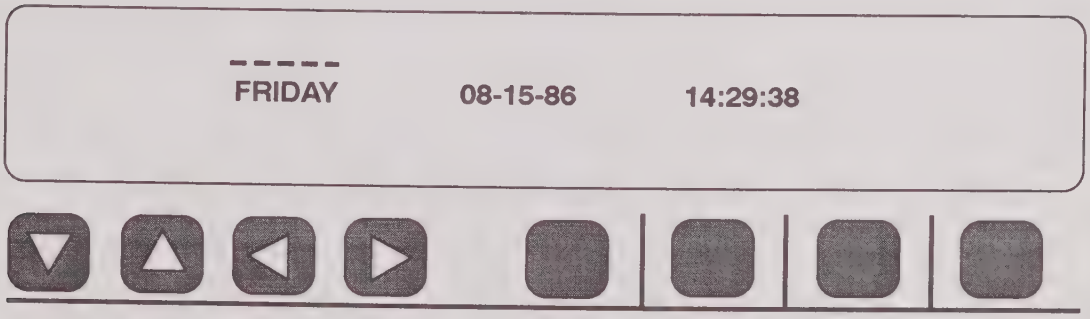
Use the LEFT/RIGHT arrow keys

to position the cursor over the day, date or time parameter it is desired to change.

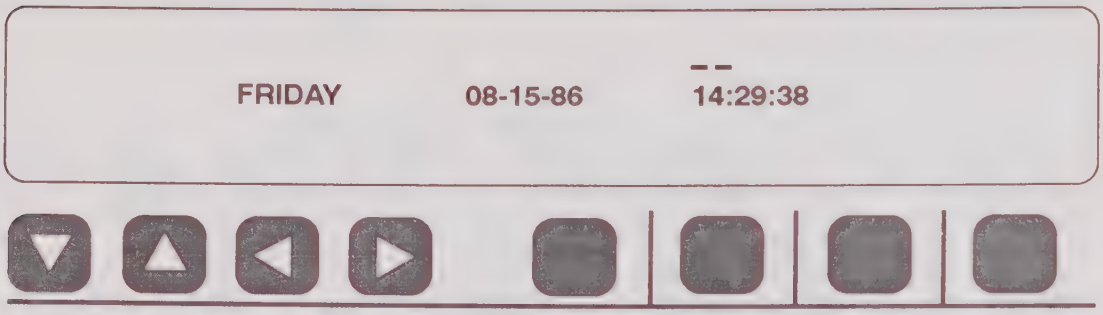
Use the UP/DOWN arrow keys

to change the parameter under the cursor.

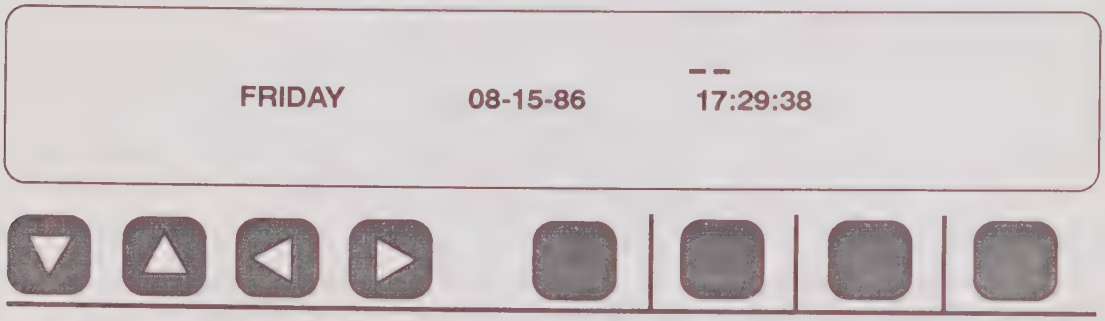
As an example, suppose it is desired to change the hour in the previous Time Date display which is repeated below.



Use the RIGHT arrow key to position the cursor over the "14" as shown:



Now suppose that it is desired to advance three hours to compensate for a time zone change from west coast to east coast time. Use the UP arrow key to advance the hour to 17 as shown below:



When the correct time and date have been set, press the OPTION MENU key to exit.

5-2 PRINTER MODE

5-2.1 INTRODUCTION

One of the most common uses of the Remote Control option is driving a printer from the RS-232C serial port. The Model 930A will work with most commonly available printers provided that the following conditions are met. The printer must have an Asynchronous RS-232C serial input port, print both upper and lower case, be ASCII compatible, and have a carriage width of at least 50 characters (preferably 80 characters). For optimum performance, the printer should accept input at 9600 baud, have at least a 2K buffer and accept continuous feed paper. Sage Instruments currently recommends the Okidata 182 with Super Speed Serial Interface. The user may obtain a printer from Sage by purchasing accessory 9400-0001-01 (80 Column Printer and Cable) if unable to obtain one locally.

Care must be exercised when attempting to use printers which do not have buffers. Such printers must be run at a speed at or below their print speed multiplied by a factor of 10. That is, an unbuffered printer with a print speed of 30 cps must be run at or below 300 baud, and an unbuffered 120 cps printer would have to be run at or below 1200 baud. Hard copy terminals, such as Teletypes and DECwriters, may also be used as printers, but their low speed tends to degrade 930A performance to an undesirable extent.

While the 930A can be connected to most serial printers without modification or special cables, experience has shown that printers vary widely in terms of interface requirements. Some may require special cables or an adaptor, in which case the user may refer back to Figure 5-2 for the pinouts of the 930A serial interface.

5-2.2 PRINT FUNCTION SET-UP

The procedure for setting up the 930A to work with a serial printer is similar to the procedure for setting up any of the remote operating modes. For this reason a brief review of the general set-up procedure follows:

1) Turn on the 930A and set up the correct Trunk Type (Section 3-6) and any test functions desired (Refer to Section 3 or 4 as necessary).

2) Press the Option Menu key and page to Menu Option 3 (Remote Control) and set the mode to "OFF" (Refer to Section 5-1.1 as necessary). Exit back to the main Option Menu by pressing Softkey 4 (labeled "EXIT"). This step prevents inadvertently dumping data to the printer and filling up its buffer before the user is ready.

3) Turn on the Printer and connect its cable to the 930A serial port.

4) Press the 930A's Option Menu key and enter Menu Option 3 by pressing any Softkey.

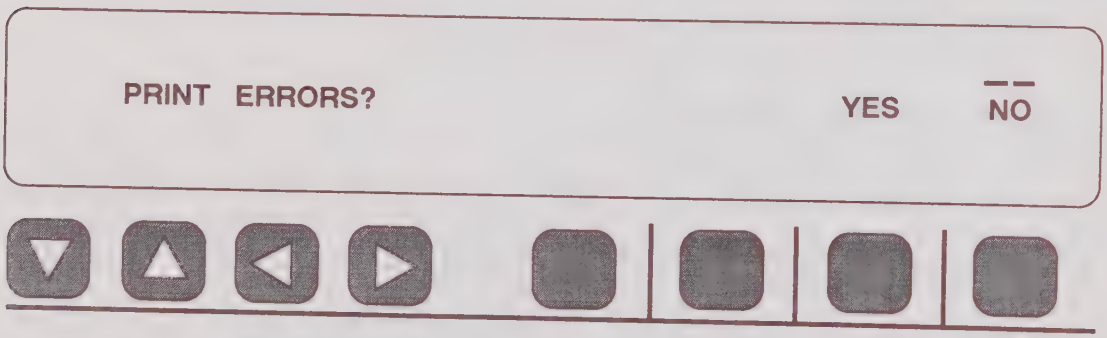
5) Once inside Menu Option 3, press Softkey 3 and enter the Set-Up menu.

6) The data format of the printer should be known or it can be determined by referring to it's operating instructions. Set the 930A's baud rate, parity, character size and stop bits to match those of the printer (Refer to Section 5-1.2 as necessary).

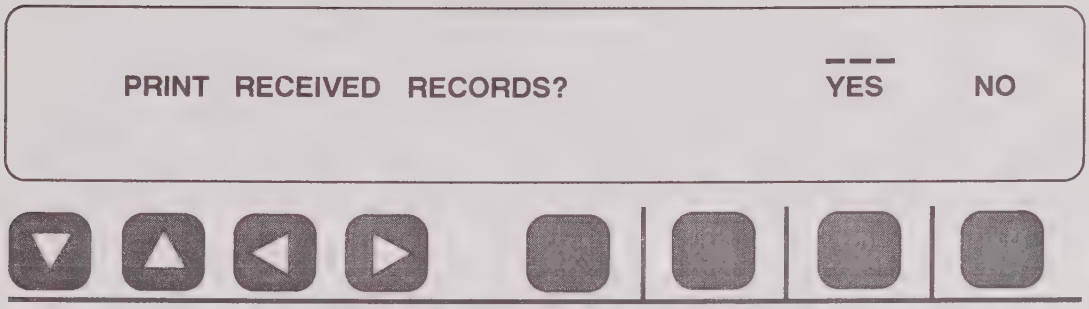
7) Once the data format has been set correctly and the 930A has returned to the Remote Control menu, the operator may use Softkey 2 to select the desired "PRINTER" mode.

8) Exit from the Remote Control menu by pressing Softkey 4 (labeled "EXIT") and the Printer mode will be initialized.

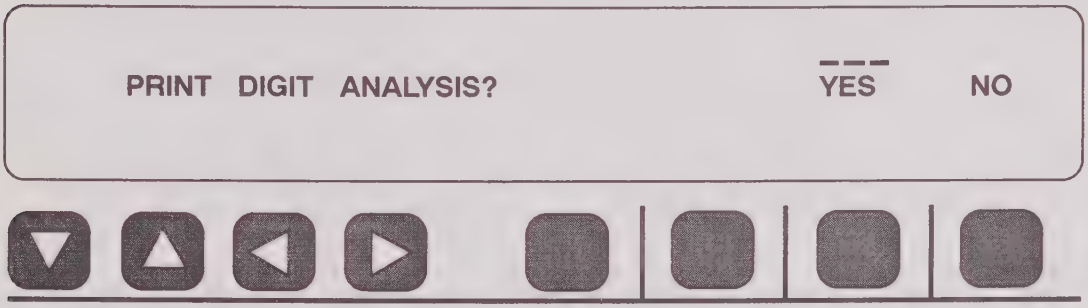
At this point, the user will be asked a series of questions by the 930A regarding what parameters are to be printed out. These questions are:



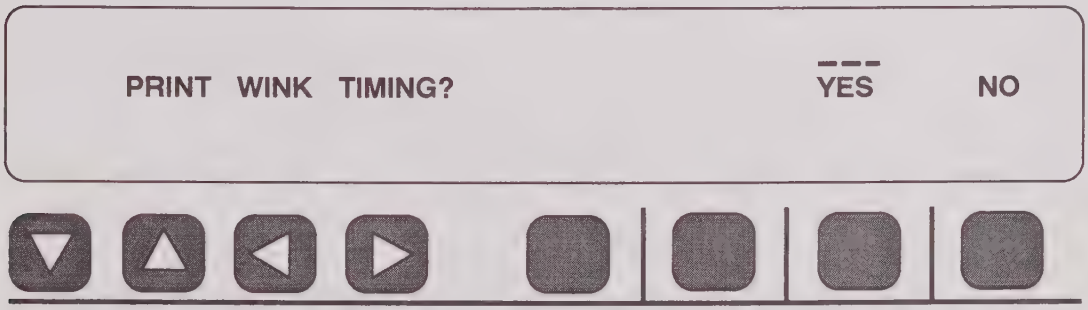
If the user desires a printout when errors occur then press Softkey 3, otherwise press Softkey 4. In either case the 930A display will advance to the next question, which is:



If a printout of all received digits is desired then press Softkey 3, and if not, then press Softkey 4. If you answer YES the display advances to:



To print the analysis of the received digits press Softkey 3. Press Softkey 4 not to print. The 930A display advances to the next question which is:



To print the wink timing parameters press Softkey 3, otherwise press Softkey 4. When the questions have been answered, the printer will begin to print whenever one of the conditions occurs or if the ENT (Enter) key on the 930A is pressed. If it is desired to suspend printing for any reason without taking the 930A out of the Printer mode, simply turn off the printer power.

NOTE: Taking the printer "Off Line" may not have the desired effect since it's buffer may fill up with unwanted material which will be printed out when the printer is placed back "On Line".

5-2.3 PRINTER APPLICATIONS

The user may always obtain a hardcopy printout of the 930A display line by simply pressing the ENT (Enter) key. This key rarely affects the display or operation of the 930A. The printout will contain a time and date stamp.

There are currently four types of information which the 930A can be set to print out spontaneously without a key press. These are : Errors, Received Digits, Digit Analysis and Wink Timing. As more options become available this list will be expanded. **NOTE:** The results of ROTL/Responder tests, frequency sweep and envelope delay measurements will be printed out automatically as they occur if the 930A is in PRINTER remote mode.

If error reporting is selected, all detected PCM errors will be time stamped and printed out as they occur. The 930A can be left to monitor a PCM channel overnight and a full error audit will be available in the morning. The list of PCM Error Messages is contained in Section 4-6.2.5.

If received record reporting is selected, received digits will be printed out whenever a Digit Receiver sequence is completed, or whenever the originating end abandons the call (goes On-Hook) in mid-sequence. The number of calls, frequency of inter-LATA vs. intra-LATA calls, and the number of incomplete ANI sequences and abandoned calls can all be determined from the 930A's reports. All reports include a time and date stamp. If Digit Analysis has also been selected, the frequency and amplitude of each MF or DTMF tone is displayed together with the interdigit time, and any spurious tones as well. Dial Pulse digits will be analyzed in terms of % Break, Pulses per second and Interdigit time.

If wink timing reporting is selected, wink timing information will be printed out whenever a record sequence is complete, a call is abandoned, or a wink fails. The 930A times supervision events such as winks when it SENDS records or when it receives records in MONITOR mode. When the 930A acts as a terminating digit receiver, it provides the winks rather than timing them. Wink timing printouts can show the time between line seizure and the first wink, the length of all winks, the time between the end of a record and a wink, and the time between call completion and answer supervision. The 930A can monitor these parameters on all calls over a given PCM channel, or analog trunk, completely unattended.

5-2.4 PRINTER REPORT FORMATS

This section provides examples of typical printouts which the 930A might generate for the various types of information. It also provides details of the report formats.

ERROR REPORTS:

An error report is a 40 character string terminated by a line feed and carriage return. The error report will have the following form:

PCM1:	NO PCM!	PCM2:	NO PCM!
	FRAME LOSS		FRAME LOSS
	SLIP		SLIP
	BIPOLAR VIO		BIPOLAR VIO
	REMOTE ALARM		REMOTE ALARM

Description: The label "PCM1:", followed by one blank, the error detected on PCM1 (if any), the label "PCM2:", and the error detected on PCM2 (if any).

RECEIVED RECORD REPORTS:

A report may consist of up to four received records. Each record is a string of 40 characters terminated by a line and feed carriage return. The final record is followed by an additional carriage return and line feed. Each record takes the form:

0123456789#*ABCD0 REC#N HOLD GATED

Description: There is a 17 character record field, followed by the label "REC#", the record number (1-4), three blanks, the word "HOLD", three blanks, and the word "RESET". Dial Pulse records can be digits from 0 to 9. DTMF records can be all digits from 0 to 9 plus the characters "A", "B", "C", "D", "*", and "#". MF records may include, in addition, the characters "KP", "ST", "STP", "ST2P", and "ST3P". There are no spaces between characters and records containing less than 17 characters are preceded by blanks.

WINK TIMING REPORTS:

Wink timing reports will include all completed or interrupted supervision events from the last record sequence received. Each supervision event is sent as three strings. Each string is terminated by a line feed and carriage return. The first string takes the form:

WINK#N

It is six characters in length and all supervision events (Winks, Off-Hooks, and Delays) are preceded by this string. The second string takes the form:

W 01 W 02 03 W H	NNNN MSEC	GUARD
(any sequence)	>16,000 MSEC	
	>60,000 MSEC	

The record sequence is printed first and may be up to 17 characters long (shorter sequences are preceded by blanks). Next, the length of the Guard period in milliseconds, or a time-out indicator, followed by the word "GUARD" is printed out. This string is 40 characters long. The third string takes the form:

W 01 W 02 03 W H	NNNN MSEC	WINK
(any sequence)	>200 MSEC	OFF-HOOK
	FAILED	DELAY

The record sequence is printed first, and may be up to 17 characters long (shorter sequences will be preceded by blanks). Next, the length of the event in milliseconds, or a time-out or failure indicator, followed by an event type label is printed out. This string is also 40 characters long. The final supervision event in the report is followed by an additional line feed and carriage return.

NOTE: If more than one type of data is included in an output, the 930A will print them out in the following order: Errors, Received Records and then Wink Timing.

5-3 OPERATION IN THE TERMINAL MODE

The Model 930A currently supports the Televideo family of terminals (the Televideo 910, 910+, 912, and 925), those terminals which can be set to emulate Televideo such as ADM, WYSE, and Hazeltine to name a few, and the VT-100 family of terminals. The former are so-called "Dumb" terminals, as distinguished from intelligent terminals, and are relatively inexpensive.

The VT-100 terminals are semi-intelligent types. The 930A supports not only the VT-100 family but also those terminals that emulate the VT-100. Since the VT-100 is ANSI standard, any ANSI terminal can be used.

Terminal emulation programs such as CROSSTALK® and PROCOMM® allow a PC to operate the 930A in Terminal Mode.

The 930A does not currently support teletypes or other "hard copy only" terminals such as DECwriters, except as Printers (Refer to Section 5-2 for details).

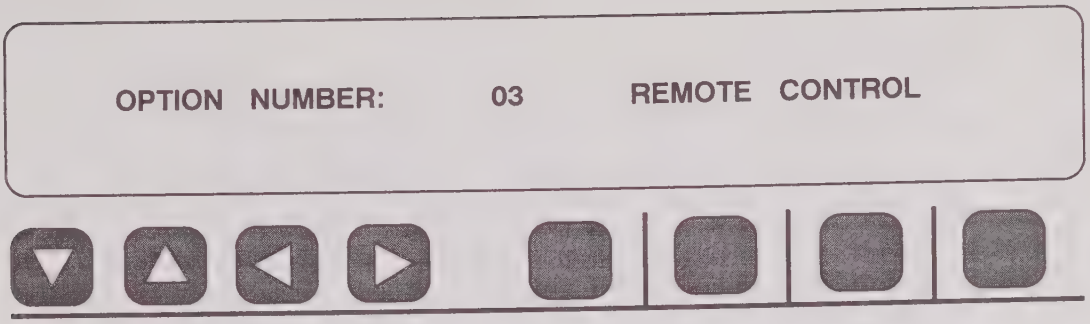
CROSSTALK and PROCOMM are registered trademarks

5-3.1 TERMINAL SET-UP

To use the Model 930A from a terminal, follow the standard set-up procedure outlined in Section 5-1.2 INTERFACE FORMAT SET-UP and Section 5-2.2 PRINT FUNCTION SET-UP. The procedure for setting up the data format of the 930A's serial port is identical for all remote modes. The steps again, in brief, are: Set the 930A Remote Mode to "OFF", connect the terminal, set the 930A's baud rate, parity, character size, and stop bits to match the terminal's data format. Set the 930A's Remote Mode to "TERMINAL". The 930A display will appear as shown below:

Press Softkey 4 (labeled "EXIT"). The 930A display will present two choices of terminal emulation as shown below:

A flashing cursor will appear over the previous Terminal emulation type used (a TVI-920 in this example). Press Softkey 2 to use Televideo 920 (or similar DUMB terminal) or Softkey 4 for DEC VT-100 terminal usage. The 930A display will immediately return to the Menu Option display as shown on the following page.



The display which should appear on the Terminal's CRT will be somewhat like that shown in Figure 5-3 below.

```
--------------------------------------------------------------------
SAGE INSTRUMENTS 930A

-------------------------------------------------
NORMAL LOOP  TERM  CONTACT  2W 900    o     t    (Current Trunk Type)
      [ J ] [ K ]  [ L ]     [ ; ]  ORIG TERM
-------------------------------------------------
A) TRUNK TYPE
B)  DIAL/RING
C) RETURN LOSS
D) SEND TONE
E) MEAS TONE
F) MEAS NOISE
G) OPTIONS

UPPERCASE   O) GO OFF HOOK   ?) HELP   CR) ENTER   SP) CLEAR
Lowercase   o) GO ON HOOK    S) STO    R) RCL     N) RCL NEXT

When sending digits:
To send: 0 1 2 3 4 5 6 7 8 9 - KP ST STP ST2P ST3P +/-
   Type: 0 1 2 3 4 5 6 7 8 9 - *  #  a   b    c    d
--------------------------------------------------------------------
```

TERMINAL CRT DISPLAY
FIGURE 5-3

NOTE: The line marked "Current Trunk Type" will show the trunk type currently selected in the 930A.

5-3.2 TERMINAL KEYS

The keys on the Terminal which affect the 930A are listed on the Terminal CRT screen together with their functions as shown in Figure 5-3. Note that each front panel key on the 930A is represented by a single key on the terminal keyboard. Pressing one of the Terminal keys, with the 930A in Terminal mode, has the same effect as pressing the equivalent key on the 930A itself. A more detailed description follows:

930A FUNCTION KEYS:

Uppercase "A" is the TRUNK TYPE key
Uppercase "B" is the DIAL/RING key
Uppercase "C" is the RETURN LOSS key
Uppercase "D" is the SEND TONE key
Uppercase "E" is the MEASURE TONE key
Uppercase "F" is the MEASURE NOISE key
Uppercase "G" is the OPTION MENU key

SOFTKEYS:

Uppercase "J" is Softkey 1
Uppercase "K" is Softkey 2
Uppercase "L" is Softkey 3
Semicolon " ;" is Softkey 4

(Note that these keys are in line on the terminal keyboard----- "J", "K", "L", ";" just like Softkeys 1, 2, 3, and 4 on the 930A.)

SPECIAL FUNCTION KEYS:

Question Mark "?" is the HELP key
Carriage Return (CR) is the ENTER key
Space Bar is the CLEAR key
Uppercase "S" is the STORE key
Uppercase "R" is the RECALL key
Uppercase "N" is the RECALL NEXT key

HOOK SWITCH:

Uppercase "O" causes the 930A to go "Off-Hook"
Lowercase "o" causes the 930A to go "On-Hook"

ARROW KEYS:

The Up, Down, Left, and Right cursor keys on the Terminal correspond directly to the Up, Down, Left, and Right Arrow keys on the 930A. A ^H (Left), ^L (Right), ^K (Up) and ^J (Down) may also be used.

NUMERIC KEYPAD:

The number keys 0 through 9 on the terminal correspond directly to the number keys on the 930A numeric keypad.

The Terminal's star key "*" sends DTMF "*", or MF "KP"
The Terminal's pound key "#" sends DTMF "#", or MF "ST"
Lowercase "a" is used to send DTMF "A", or MF "STP"
Lowercase "b" is used to send DTMF "B", or MF "ST2P"
Lowercase "c" is used to send DTMF "C", or MF "ST3P"
Lowercase "d" is used to send DTMF "D"
Lowercase "d" is also used as the change sign "+/-"

Further details of the keyboard input including ASCII to HEXADECIMAL and ASCII to Decimal code equivalents are contained in Section 4-4 COMPUTER OPERATION.

5-3.3 TERMINAL CRT DISPLAY

Most of the CRT is dedicated to displaying a HELP screen. Only one line of the CRT changes to indicate the status of the 930A and it is set off from the others by a dotted line. It always echoes the display on the 930A front panel. In the example of Figure 5-3 the line was:

```
----------------------------------------------------------

   NORMAL LOOP    TERM    CONTACT    2W 900     o      t

----------------------------------------------------------
```

The "[J] [K] [L] [;]" below the changing display line in Figure 5-3 is meant to reflect the position of the four Softkeys under the 930A front panel display. The equivalent keys on the terminal ("J", "K", "L", and ";") line up below the functions just as Softkeys 1-4 do on the 930A. A Softkey's function is usually indicated by the display above it. The entire display line, using Figure 5-3 as an example, looks like:

```
----------------------------------------------------------

   NORMAL LOOP     TERM     CONTACT     2W 900     o      t
         [ J ]   [ K ]    [ L ]       [ ; ]   ORIG  TERM

----------------------------------------------------------
```

A portion of the display line has the words "ORIG" and "TERM" beneath it.

These fields show the condition of the 930A's supervision lamps. The lowercase "o" and "t" in the display above indicate that both the originating and terminating ends are "On Hook". An uppercase "O" or "T" indicates an "Off Hook" condition at the originating or terminating end. A "-" in either location means "no indication", and generally signifies an incomplete or faulty circuit.

5-3.4 TROUBLESHOOTING

SYMPTOM: Terminal CRT remains blank.
PROBABLE CAUSE: Faulty or improper RS-232 cable connection.
APPROACH: Check cables, power to the terminal, and RS-232 pinouts.

SYMPTOM: Terminal prints gibberish.
PROBABLE CAUSE: Incorrect data format.
APPROACH: Turn terminal off. Set 930A Remote Mode to "OFF". Check 930A baud rate, parity, character size, and stop bits. Check terminal DIP switches to be sure of it's data format. Turn terminal on. Set the 930A remote mode to "TERMINAL" and press Softkey 4 to "EXIT".

SYMPTOM: The 930A does not respond to terminal commands.
PROBABLE CAUSE: Bad mechanical connection or CAPS LOCK not down.
APPROACH: For mechanical condition, check the cables and connectors (broken pins), power, and RS-232 pinouts. For CAPS LOCK be sure that Uppercase commands are being sent when intended. The 930A uses only a few lowercase commands so the CAPS LOCK key on the terminal should generally be down.

SYMPTOM: 930A responds to some commands but not others.
PROBABLE CAUSE: Broken lead in RS-232 cable or wrong data format.
APPROACH: For data format, refer back to the "gibberish" symptom. Test the RS-232 cable with an ohmmeter or by replacing with another cable.

5-4 COMPUTER OPERATION

5-4.1 INTRODUCTION

The 930A can be operated under the control of any computer capable of sending and receiving serial ASCII characters over an RS-232 link. Each character sent to the 930A is treated as a keystroke from the 930A's front panel. A single ASCII character has been selected to represent each key on the front panel of the 930A. Sending the ASCII character is the equivalent of pressing the 930A key associated with it. For example, sending the Uppercase ASCII character "A" is the same as pressing the Trunk Type Function key. Writing a program for the 930A is just like writing a program for a programmable calculator. That is, do the operation manually and write down the key sequence. Then translate the key sequence into an ASCII string. Sending the string causes the operation to be performed. Refer to Table 5-1 for ASCII to front panel conversions as well as HEX and Decimal equivalents.

It is strongly recommended that the Terminal mode be used when writing or debugging programs intended for use in the Computer mode. Terminal mode is fully interactive and comes with onscreen HELP.**

There are a few ASCII characters (H, M, m, W, X, Y and Z) that will cause the 930A to perform special functions that are only performed remotely. These characters do not correspond to any keys on the 930A front panel. Refer to Table 5-2 for details.

** To operate the 930A in Terminal Mode from a PC, use a terminal emulation program such as CROSSTALK or PROCOMM.

TABLE 5-1
ASCII TO FRONT PANEL KEY CONVERSION

ASCII CHARACTER	930A FUNCTION	HEX CODE	DECIMAL CODE
A	Trunk Type	41	65
B	Dial/Ring	42	66
C	Return Loss	43	67
D	Send Tone	44	68
E	Measure Tone	45	69
F	Measure Noise	46	70
G	Option Menu	47	71
RETURN	Enter	0D	13
SPACE	Clear	20	32
?	Help	3F	63
S	Store	53	83
R	Recall	52	82
N	Recall Next	4E	78
d	Change Sign (+/-)	64	100
-	Pause (Left Arrow)	2D	45
Uppercase O	Go Off Hook	4F	79
Lowercase o	Go On Hook	6F	111
J	Softkey 1	4A	74
K	Softkey 2	4B	75
L	Softkey 3	4C	76
;	Softkey 4	3B	59
^H (Left Cursor)	Left Arrow	08	8
^L (Right Cursor)	Right Arrow	0C	12
^K (Up Cursor)	Up Arrow	0B	11
^J (Down Cursor)	Down Arrow	0A	10

TO SEND	TYPE	HEX	DEC	TO SEND	TYPE	HEX	DEC
0	0	30	48	*	*	2A	42
1	1	31	49	#	#	23	35
2	2	32	50	A	a	61	97
3	3	33	51	B	b	62	98
4	4	34	52	C	c	63	99
5	5	35	53	D	d	64	100
6	6	36	54	KP	*	2A	42
7	7	37	55	ST	#	23	35
8	8	38	56	STP	a	61	97
9	9	39	57	ST2P	b	62	98
				ST3P	c	63	99

TABLE 5-2
SPECIAL ASCII CHARACTERS FOR REMOTE CONTROL

CHARACTER	FUNCTION	HEX	DEC
H	Causes the 930A to send a copy of it's terminal HELP screen (See Figure 5-3) to the remote computer or terminal.	48	72
m	Causes the MODEM to go "ON-HOOK".	6D	109
W	Causes the 930A to report all pending PCM errors, received records, and wink timing information to the host computer. Information is "pending" when an ALERT has been sent but no REPORT has been requested.	57	87
X	Interrupts the 930A and causes it to send an immediate copy of it's current display line to the host computer. This command is not buffered and executed in turn. It is executed at once.	58	88
Y	Causes the 930A to send a copy of it's current display line to the host computer. This command is buffered and executes after all previous commands have been completed.	59	89
Z	Causes the 930A to send a copy of it's current display line after it determines that a valid measurement has been made. A series of consecutive "Z" commands will cause the 930A to send consecutive measurements to the host computer.	5A	90

NOTES: The "X", "Y", and "Z" commands all cause the 930A to send a copy of it's display line to the host computer.

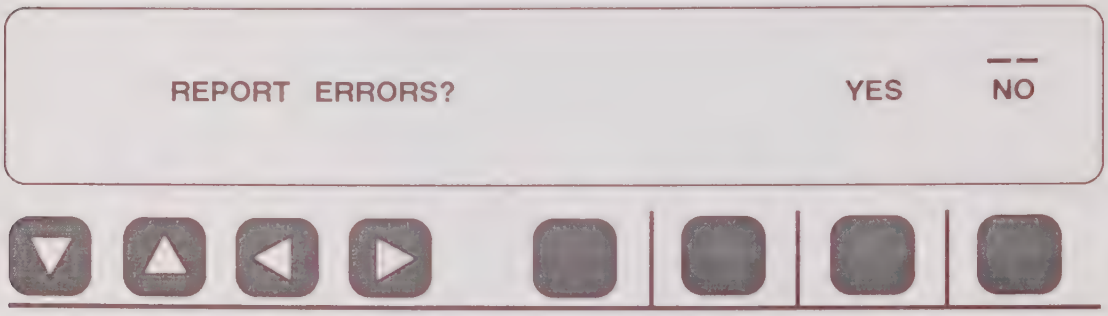
The "X" command executes immediately and can be used to find the current status of the 930A. This allows "spot checking" progress through a command sequence at any time.

The "Y" command tells the 930A to send a copy of it's display line when it reaches a certain point in the command sequence. This can be used to obtain a measurement or start a timer in the host.

The "Z" command is like the "Y" command, except that successive "Z" commands will each be delayed by one measurement period.

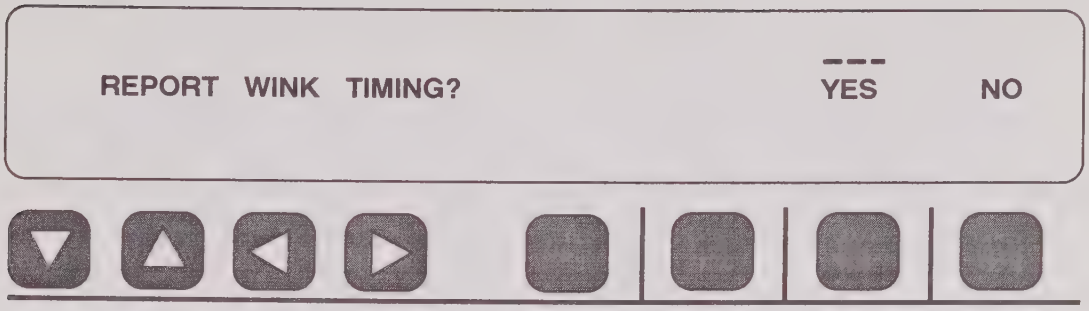
5-4.2 COMPUTER MODE SET-UP PROCEDURE

The RS-232 interface set-up procedure for the Computer Mode of the 930A is the same as outlined in Sections 5-1.2 and 5-2.2. To review: set the 930A's Remote Mode to "OFF". Connect the computer to the 930A serial port. Use the Set-Up menu to set the 930A's baud rate, parity, character size, and stop bits. Set the Remote Mode to "COMPUTER" and press "EXIT". The 930A will ask the following questions:



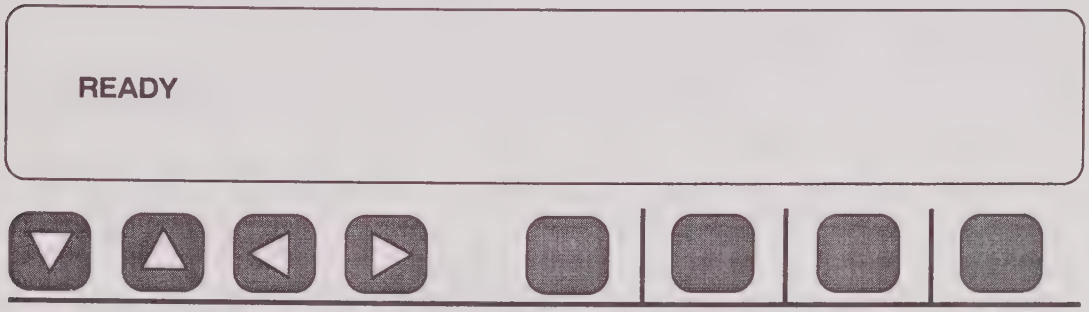
Press Softkey 3 if it is desired to have the 930A alert the host computer when it detects PCM errors. Press Softkey 4 if no alert for PCM errors is required. The display will advance to the next question:

Answer Yes by pressing Softkey 3 if it is desired to have the 930A alert the host computer upon completion or interruption of a Received Record sequence. Otherwise, press Softkey 4. The 930A display automatically advances to the next question.



Answer Yes by pressing Softkey 3 if the 930A is to alert the host computer when it has wink timing information available. Otherwise press Softkey 4.

The 930A display should then read:



A prompt will then be sent to the host computer to indicate that the 930A's command buffer is empty and the 930A is awaiting instructions.

5-4.3 INPUT TO THE 930A

Input to the 930A is in the form of "command strings". These are strings of ASCII characters that the 930A recognizes as commands. A command string may be from 1 to 40 characters in length. The 930A has a 40 character input buffer. Tables 5-1 and 5-2 contain summaries of these commands and Section 5-3.2 describes them.

The 930A will echo each character back to the computer as it is received and placed in the buffer. DO NOT SEND THE NEXT CHARACTER UNTIL THE ECHO HAS BEEN RECEIVED. This is the 930A input protocol (actually a handshake). The 930A will execute the commands in the order they are received, with the exception of the "X" character which executes immediately. When all of the received commands have been executed, and the input buffer is empty, the 930A will signal the host computer with a prompt.

The 930A will echo and ignore any characters it does not recognize as commands. No error message is sent back.

5-4.4 OUTPUT FROM THE 930A

Output from the 930A consists of the following:

ECHOES --- The 930A echoes all received characters to the host computer.

PROMPTS - When the 930A has executed all received commands, and its command buffer is empty, it sends a prompt consisting of a line feed, carriage return, and a ">" character. The ASCII sequence in Hexadecimal code is 0A 0D 3E. Some data strings include the ">" character, but the 0D 3E sequence is unique.

ALERTS -- Under certain circumstances, the 930A will send a "bell" character (ASCII 07) to alert the host computer that it has something to report. Any programs the user writes should screen all 930A output carefully for this character. If the Beep on Error feature (Menu Option 15) is turned "OFF", no bell character will be sent.

DATA ---- When the 930A executes an X, Y, or Z command, it sends a copy of it's current display line and supervision status. This is a 50 character line terminated by a line feed and carriage return. Section 4-4.5 contains details of display line formats.

REPORTS - If the 930A has sent the host computer an ALERT, it will respond to the "W" command with a report concerning what caused the ALERT. This could be a PCM error, a completed Receive Record sequence, Wink Timing information, or some combination of the three. Section 5-2.4 contains further details of Report Formats. When used as a Near End Responder (Menu Option 26), the 930A will send an alert (Bell) at the completion of each test.

5-4.5 DISPLAY LINE FORMATS

A Display Line is always 50 characters long terminated by a line feed and carriage return. The first 40 characters of a Display Line mirror the display on the front panel of the 930A. The next 4 characters are ASCII blanks. The forty-fifth character shows originating supervision. The next 4 characters are ASCII blanks. The fiftieth character shows terminating end supervision. Typical displays which might show up on the computer's CRT screen are provided as examples.

TYPICAL CRT DISPLAYS:

MEASURE TONE:

NNNN Hz	**+NN.N**	**dBm0**	**PCM1**	**BRIDGE**	**O**	**T**
----	**OVER**	**dBm**	**PCM2**	**TERM**	**o**	**t**
	----	**dB**	**T1R1**		**-**	**-**
	----	**dB**	**TR**		**-**	**-**

Description --- Seven leading blanks, followed by the frequency in Hertz or four dashes, the label "Hz ", a signed level or the over or under indication ("OVER" or "----"), the relative zero label, the signal source label, and the termination label.

MEASURE NOISE:

+NNN	**dBrn0**	**C-NOTCH**	**PCM1**	**CHANNEL**	**O**	**T**
	dBrn	**3K FLT**	**PCM2**	**N-TO-G**	**o**	**t**
	dB	**C-MSG**	**T1R1**	**BAL**	**-**	**-**
	dB	**S/N**	**TR**			

Description --- Three leading blanks, followed by a signed level measurement, the relative zero label, the filter type, the signal source label, and the type of measurement.

RETURN LOSS:

4 WIRE:

+NNNdB	SRL LO NNNNHz +NN THL	4W 1200	O	T
	SRL HI	4W 900	o	t
	ERL	4W 600	-	-
	OSC	PCM1		
		PCM2		

Description --- Two leading blanks, followed by a signed level measurement and the label "dB", the signal type, the frequency of the echo suppress tone or the oscillator tone and the label "Hz", a signed trans-hybrid loss level and the label "THL", and a trunk type label.

2 WIRE: -- NORMAL:

+NNNdB	SRL LO NNNNHz	2W 1200	O	T
	SRL HI	2W 900	o	t
	ERL	2W 600	-	-
	OSC	2W 150		

Description --- Two leading blanks, followed by a signed level measurement and the label "dB ", the signal type, the frequency of the echo suppress tone or oscillator tone and the label "Hz", ten blanks, and a trunk type label.

2 WIRE: -- TR TERM:

TR TERM	AC SHORT 2W	O	T
	AC OPEN	o	t
	900+2.16	-	-
	600+2.16		

Description --- 9 leading blanks, followed by the label "TR TERM" and an additional 8 blanks, a circuit descriptor label, and the "2W" descriptor with 9 trailing blanks.

In the previous examples of typical CRT displays, the numerical data format needs to be explained in more detail. That is, numbers were denoted by a single "N" for each possible digit with the understanding that this "N" was showing location rather than numerical value. In point of fact, each "N" could stand for any number. If a decimal point were present, it was shown as a "." . Signed numbers were shown being preceded by a "+" character. In practice, this could be either a "+" or "-".

Leading zeroes will be printed as blanks and trailing zeroes will be printed as zeroes. The digit to the left of the decimal point will always be printed, even if it is a leading zero. The sign of the number will always be printed to the left of the first non-blank digit.

For example: A number which was represented by "+NN.N" in the above typical displays could be any of the following in actual practice:

+99.9, -1.0, +0.0, -0.4, +7.4

5-4.6 PROGRAMMERS NOTES

This Section is currently under review and will be supplied at a later date.

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SECTION VI
VOICE FREQUENCY MEASUREMENT PRINCIPLES

6-1 INTRODUCTION

This section is meant to augment Section III and contains useful background information on voice channel impairments and their measurement on voice frequency trunks carrying message and data communications.

The telephone network today carries voice, data, telegraph, facsimile and other services although it was originally designed to support only voice. The modern telephone network uses both analog and digital transmission facilities.

Voice communication is two-way, at relatively slow speed and has the wide dynamic range of human speech. Because of the redundancy inherent in speech communication and the intelligence of the listener and talker, many of the deficiencies in the transmission medium can be overcome.

Digital data however, is a high speed information transfer, either one-way or two-way, and with a narrow dynamic range. Data is sensitive to the transmission medium's deficiencies since these can cause errors. Analog transmission systems are less than optimum for digital data.

To transmit or receive a digital data signal over an analog voice frequency facility, a MODEM (Modulator, Demodulator) is used. This device converts the digital data signal into analog tones which can be passed over the network, and vice versa.

Modems, or data sets as they are called, are sensitive to certain analog parameters which have no effect on speech. This sensitivity increases as the data rate increases. It is not at all uncommon for people to be able to speak over lines which are unusable for data.

The most significant analog parameters affecting data communications are bandwidth of the channel, mode of transmission and line impairments. These parameters can be specified to some extent by the user and some are controlled by FCC tariffs.

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6-2 BANDWIDTH

The bandwidth of a channel defines its useable frequency range. The maximum speed of data transmission is directly related to the bandwidth. There are three grades of bandwidth:

Narrowband	(0 to 300 Hz)
Voice Band	(300 to 4000 Hz)
Wide Band	(> 4000 Hz)

Narrowband, sub-audio channels allow transmission speeds from 45 to 300 bits per second and are used for data only. Voice transmission is impossible. Narrowband is used for Teletype, Facsimile and low speed modem data.

Voice band channels (300 to 4000 Hz) can support a wider range of data rates. Modern modems are available which can operate at rates of up to 16.8 Kbps on voice band channels. The majority of modems operate at speeds between 300 and 4800 bps although the voice band channel can support rates between 60 bps and 19.2 Kbps. At the higher rates most modems operate in the half-duplex mode. Voice band channels are available as either dial-up (public switched network or switched special services) or as leased lines (private, dedicated point-to-point non-switched service).

Dial-Up or Switched Services

Dial-up lines are the most common form of service and use the established switched network. A dial-up call may route through a number of switches to reach its destination. The switches may be older electro-mechanical types, or modern digital machines or combinations. Electro-mechanical switches are a major source of impulse noise on dial-up lines. Since dial-up lines can have a different path for each call placed, it is impossible to condition a dial-up circuit for data signals. While impulse noise or noise alone may be annoying during a conversation, voice communication is still possible. However, impulse noise can render data communications impossible.

The lack of conditioning generally restricts the speed of data transmission to less than 9600 bps over dial-up lines and at such a high rate the distance would usually have to be short (< 50 miles) as well. This of course assumes that a modern modem with adaptive equalization and error correction coding is used. These restrictions are the reason that the most

frequently used rates on dial-up lines are 300 bps and 1200 bps.

The dial-up network has the advantage of redundancy. If the first line does not permit data communication, hang up and re-dial. The second line will almost certainly be different.

Leased Lines

Leased lines, sometimes referred to as private lines or "nailed-up" circuits, are point-to-point dedicated connections between locations. These dedicated lines are used in private data networks and are independent of switching and signaling equipment in the telephone central office.

Since the circuit always has the same transmission path, it can be conditioned (shaped) to allow higher speed data transmissions reliably. Data speeds above 9600 bps are possible with proper conditioning and the restrictions on distance are less severe.

Line conditioning is discussed in Section 6-4.1.

Wideband

Wide band lines consist of a bundle of voice channels. Data speeds of up to 56 Kbps are possible on Series 8000 service. This service is quite expensive and is not in common use. Wide band analog transmission has given way to digital (either DDS or T-1 Carrier) service.

Digital Transmission

Point-to-point transmission service eliminates the need for modems. The signal is regenerated along the path so that there is negligible noise accumulation and signal degeneration. Lower error rates result and speeds of up to 1.544 Mbps are now available to the end user. These are no longer single voice channels but trunks capable of handling voice and data simultaneously using multiplexing techniques.

6-3 TRANSMISSION MODES

Another parameter which affects data communications is the mode of transmission. The transmission mode is usually the source of the impairments discussed in the next section. The sources are described in this section.

The transmission path for voice frequency signals is commonly referred to as a two-wire or a four-wire circuit. Two-wire cable is usually found in the "subscriber loop" between the telephone company end office or wire center and the telephone set on dial-up lines. Four-wire circuits are normally used between telephone central offices or as leased lines. Although called a four-wire circuit, it is not unusual for a four-wire toll circuit to be a microwave radio, coaxial cable, satellite or fiber optic facility or a combination of these types.

Sources of Transmission Impairments

The two and four wire circuits which are provided by copper wire cable are referred to as "metallic" facility in the telephone companies to delineate them from other types of transmission media. Metallic facility is, as might be expected, the most common transmission medium. However, the transmission medium can introduce impairments. Copper wire has resistance and pairs of wires have capacitance between them. Both of these parameters can attenuate the signal. The amount of attenuation depends upon cable length, signal frequency, proximity to power lines, and weather conditions if the line is in open air. More sources of impairments follow.

Coaxial Cable

Coaxial cable consists of up to twenty "tubes" enclosed by a protective sheath. Each tube has a copper center conductor suspended by insulation. Since the tube and center conductor share a common center axis, it is called coaxial. At one time these cables were the principle means of carrying long distance (toll) traffic but were rapidly superseded by microwave radio. Coaxial cables use repeaters spaced at one to four mile intervals. The voltage which powers them is sent down the center conductor along with the signal energy. This voltage may be as much as 1600 volts. In older cables, it is not uncommon for arcing to occur between the center conductor and tube surrounding it due to deterioration of the insulation. These arcs cause noise spikes and a general increase in noise level.

Microwave Radio Relay

Microwave radio relay systems consist of stations spaced about 30 miles apart. Each station has radio and may have multiplex equipment at intermediate sites along the backbone route. Microwaves travel in straight lines so the stations antenna towers must be within line of sight of each other. Each station amplifies and re-transmits the signal.

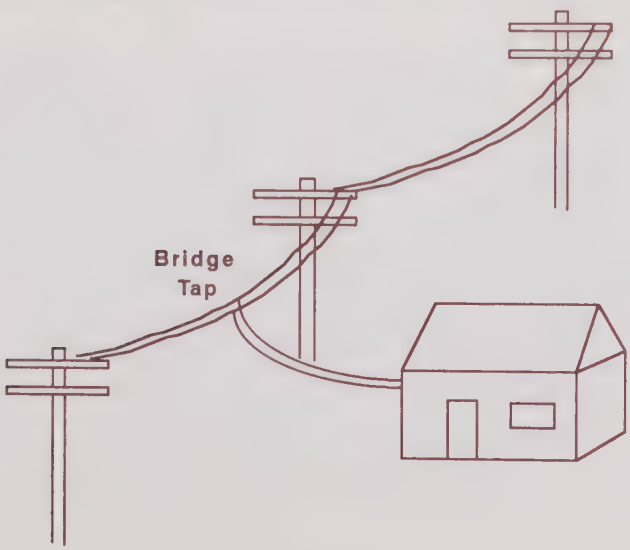
Microwave propagation is adversely affected by weather conditions and path anomalies. Changes in signal amplitude are referred to as "fading". If the fading is severe enough, the radio's protection switching system may switch to an alternate path or frequency. Fading can therefore result in phase distortion and dropouts.

Satellite Facility

Long distance dial-up calls may be routed over satellite facility. The delays involved in propagation over such a path may be too much for a modem. The turnaround time of the modem is almost certain to be less than the delay. The user has no control over the path chosen by the switch on dial-up calls. It is conceivable that one direction might go via satellite with the return path being on terrestrial microwave. Satellite paths may cause complete loss of data communication capability.

Bridge Taps

A bridge tap is formed by bridging across the cable pairs to bring service to a customer as shown below:



When service is disconnected, the wires are left in place but are unterminated. The capacitance these unterminated wires present to the circuit can produce significant phase distortion. Conditioned lines have all bridge taps removed. However, a regular dial-up call cannot be sure that bridge taps are not present. This limits home computer users to less than 1200 bps modems more than any other factor with the possible exception of load coils which are discussed next.

Load Coils

Loading coils are placed at approximately 6000 foot intervals on subscriber loops. Loading coils reduce attenuation distortion by smoothing attenuation over a given frequency range to a nearly constant amount. Load coils act as filters in that they have a limited frequency bandpass. Above 4 KHz the load coils attenuation increases drastically. Data, with its sharp transitions, has high frequency components above 4 KHz. Attenuating these high frequency components distorts the shape of the digital signals. This distortion leads to increased error rates.

Repeaters

Voice frequency repeaters are amplifiers which compensate for attenuation on long circuits. VF repeaters have a gain or amplification factor of about 23 dB. Any active device such as an amplifier is inherently non-linear. This means that additional frequencies may be present at the output of the repeater that were not present at the input. This comes from the "mixing" of input frequencies to produce sum and difference frequency products at the output. This is called intermodulation distortion. Another form of non-linear distortion causes integer multiples of the input frequencies to appear at the output and is referred to as harmonic distortion. Amplifiers also amplify the unwanted noise and distortion which appear at their inputs as well as the desired signal. This accumulation of noise and distortion on long distance calls limits the data speed and increases the error rate. Modern all digital transmission media such as fiber optic facilities do not accumulate noise because the signal is completely regenerated at each fiber optic repeater location and the signal to noise ratio does not deteriorate.

Hybrids

The two-wire facility which comprises applications such as subscriber loop and PBX trunks must interface to the four-wire toll network for long distance or inter-office calls. This is accomplished in the telephone network by using a 2W/4W hybrid network. In its simplest form a hybrid is a transformer with a tapped winding. The conversion from two-wire to four-wire and vice versa usually takes place in the end office or serving office nearest the customer. The path can be converted at intermediate points as well.

The problem with hybrids is that they present a discontinuity to the circuit. No matter how small, the discontinuity has a direct impact on transmission. A portion of the energy incident upon a discontinuity, or impedance mismatch, is reflected back. If the energy is speech, then a portion of the energy reflected back toward the talker is his own speech. This is referred to as echo. It is most discernible on long distance calls, particularly over satellite links, but may also be found on local calls where the echo makes the talker feel like he is talking into a barrel. If the discontinuity is small and the network is reasonably well matched then the reflected energy is small and not noticeable. If the mismatch is large then the talker will experience echo.

Echo Suppressors/Cancellers

To prevent, or at least diminish, echo on switched long distance calls, echo suppressors and more recently, echo cancellers are used.

Echo suppressors insert attenuation into the return path to reduce the echo. Echo cancellers employ a complex feed forward technique which mixes echo path response with the incoming desired signal to produce an error voltage. This error voltage is used as an estimate of the echo. This estimate is subtracted from the echo path output thereby "cancelling" the echo.

Echo cancellers and suppressors, while they remove an impairment to voice communications, create a possible impairment to data signals. These devices must be removed from the transmission path during data communications or they attenuate the reverse direction of full duplex modems. To disable these devices during data transmission, a 2125 Hz disable tone is transmitted on the path for at least 400 milliseconds prior to data transmission. This tone is sent by the modem. During turnaround time or when data is absent, the modem transmits the disable tone to keep

the suppressors/cancellers disabled. When the modem carrier tone is absent for more than 100 milliseconds, the suppressors/cancellers are re-enabled for voice.

The 400 millisecond delay in disabling the suppressor/canceller can be a serious limitation when using dial-up lines for half duplex interactive transmission. Each direction of transmission requires a disable so there would be two disable delays. Many modern half duplex modems can turn off both echo suppressors/cancellers at the start of transmission.

Echo suppressors and cancellers are not used on leased lines, only on dial-up.

Compandors

A compandor consists of a Compressor and an Expandor. The compressor reduces the transmitter volume range by lowering high amplitude signals and raising low amplitude signals. On the circuit then, the signal has a compressed volume range during transmission. At the receiving end the expandor reverses the process and restores the signal to its original range.

At the transmitter, since noise is not a significant presence, the noise level is not increased by the compressor. At the receive end, the expandor restores the signal and spreads out any noise accumulated on the path thereby lowering the effective noise level.

Although this improves the signal to noise ratio on the line for voice traffic, it can adversely affect data signals. Amplitude modulated data signals transmitted through a compandor will be severely distorted by the variable loss characteristic of the compandor. Since compandors are non-linear devices, frequency shift key modems can also be affected by the introduction of spurious frequencies.

Compandors must be disabled before data transmission.

Equalizers

Equalizers can be either active or passive circuits. Equalizers are added to voice grade leased lines to smooth out the attenuation and delay response characteristics across the channels bandwidth. Passive or fixed equalizers compensate for average line conditions and cable length. Adaptive

equalizers in modern modems track and compensate for changes in a lines characteristics. However, rapid changes in line characteristics can cause the modem to lose sync and data because the adaptive equalizer cannot track and initialize on the change fast enough.

6-4 TRANSMISSION IMPAIRMENTS

A number of parameters can affect data transmission on voice channels. These impairments may be either steady state or transient in nature. This section describes the impairments. The previous section discussed some of he sources of these impairments. Section 6-5 describes their measurement using the Model 930A.

Attenuation distortion and envelope delay distortion are two parameters that define a channels frequency response and bandpass. FCC tariff No. 260 establishes the different limit levels and equalizers are used to control these parameters. Noise level and non-linear distortion are also controlled by tariffs.

Frequency shift, impulse noise, phase and amplitude jitter, and transients such as dropouts, phase hits and gain hits are controlled by internal telephone company standards but are not tariffed.

6-4.1 LINE CONDITIONING

Telephone companies offer leased lines with several types of line conditioning to provide higher data rates and/or reduce error rates. Before describing impairments it is useful to discuss the conditioning limits against which impairments are measured. Conditioning is usually required for data speeds in excess of 2400 bps and should definitely be used above 4800 bps.

The conditioning levels are specified in FCC Tariff No. 260. There are six levels of conditioning commonly used (although there are others). Tariff No. 260 provides a basic non-conditioned voice channel designated as series 3002 service. The tariff also defines other types of conditioning including five types of C-conditioning which are commonly used. In addition to these services, some telephone companies provide an option for high speed data above 9600 bps called D-conditioning. C-conditioning is the name given to the channel treatment which makes voice grade lines meet the conditioning specifications of Tariff 260. These specifications apply to the attenuation and envelope delay distortion characteristics of the channel. C-conditioning is applied to the basic 3002 service. The removal of loading coils may be included in the circuit treatment by specifying B-conditioning. B-conditioning is needed for short haul modems or line drivers. Table 6-1 shows the conditioning levels for the various types of conditioned lines.

	Non-Conditioned 3002 Channel		C1 Conditioning		C2 Conditioning		C3 Conditioning (Access Lines)	
Frequency Range (Hertz)	300-3000		300-3000		300-3000		300-3000	
Attenuation Distortion (Net Loss at 1 KHz)	Frequency Range	Decibel Variation	Frequency Range	Decibel Variation	Frequency Range	Decibel Variation	Frequency Range	Decibel Variation
	300-3000	-3 to +12	300-2700	-2 to +6	300-3000	-2 to +6	300-3000	-0.8 to +3
	500-2500	-2 to +8	1000-2400	-1 to +3	500-2800	-1 to +3	500-2800	-0.5 to +1.5
			300-3000	-3 to +12				
Envelope Delay Distortion (Micro-seconds)	Less than 1750 usec from 800 to 2600 Hz.		Less than 1000 usec from 1000 to 2400 Hz. Less than 1750 usec from 800 to 2600 Hz.		Less than 500 usec from 1000 to 2600 Hz. Less than 1500 usec from 600 to 2600 Hz. Less than 3000 usec from 500 to 2800 Hz.		Less than 110 usec from 1000 to 2600 Hz. Less than 300 usec from 600 to 2600 Hz. Less than 650 usec from 500 to 2800 Hz.	
Signal to Noise (dB)	24		24		24		24	
Non-Linear Distortion Signal to 2ND Harmonic (dB)	25		25		25		25	
Signal to 3RD Harmonic (dB)	30		30		30		30	

C3 Conditioning (Trunk)		C4 Conditioning		C5 Conditioning		D Conditioning
300-3000		300-3200		300-3000		
Frequency Range	Decibel Variation	Frequency Range	Decibel Variation	Frequency Range	Decibel Variation	
300-3000	-0.8 to +2	300-3200	-2 to +6	300-3000	-1 to +3	
500-2800	-0.5 to +1	500-3000	-2 to +3	500-2800	-0.5 to +1.5	
Less than 80 usec from 1000 to 2600Hz. Less than 260 usec from 600 to 2600 Hz. Less than 500 usec from 500 to 2800 Hz.		Less than 300 usec from 1000 to 2600Hz. Less than 500 usec from 800 to 2600 Hz. Less than 1500 usec from 600 to 3000 Hz. Less than 3000 usec from 500 to 3000 Hz.		Less than 100 usec from 1000 to 2600Hz. Less than 300 usec from 600 to 2600 Hz. Less than 600 usec from 500 to 2800 Hz.		
24		24		24		28
25		25		25		35
30		30		30		40

TABLE 6-1. LINE CONDITIONING LIMITS

C-conditioning on multipoint circuits applies to all of the links on the circuit. The same circuit cannot have a mixture of different types of C-conditioning. That is, one leg of a bridge circuit cannot be a 3002 line while the other links are C2 for example.

Basic 3002 channels and channels with C1 and C2 conditioning may be ordered in point-to-point, multipoint and switched configurations.

C3 conditioning applies only to private switched networks and is specified in terms of access lines and trunks. C3 conditioning ensures an overall C2 conditioning level end-to-end on switched connections involving up to four trunks and two access lines in tandem. C3 conditioning is used on Common Control Switching Arrangement (CCSA) or switched circuit automatic networks which are independent of the regular dial-up network.

C4 conditioning can be ordered only for two, three, or four point operation. C5 conditioning can only be ordered for two point operation. C5 conditioning is meant to achieve C2 conditioning end-to-end on multiple link connections. The principal use of C5 conditioning is on two point private lines which extend overseas.

D-conditioning is an option introduced by the telephone companies to handle 9600 bps and above modems. D-conditioning controls signal to noise ratio and non-linear distortion more closely than C-conditioning which focuses mainly on attenuation and envelope delay distortion.

When using modems with adaptive equalizers, C-conditioning may not help performance. This is because unconditioned or lightly conditioned lines have smooth envelope delay curves while C2 and C4 lines have steep slopes and ripples in the passband which make it difficult for adaptive equalizers to stabilize.

6-4.2 VOICE CHANNEL IMPAIRMENTS

The impairments which affect data transmitted over voice channels have limits specified in FCC Tariff No. 260 or in telephone company internal standards.

The tariffed parameters include attenuation distortion, envelope delay distortion, noise and non-linear distortion. Those parameters not specified in Tariff 260 include return loss, impulse noise, gain hits, phase hits, dropouts, and phase and amplitude jitter.

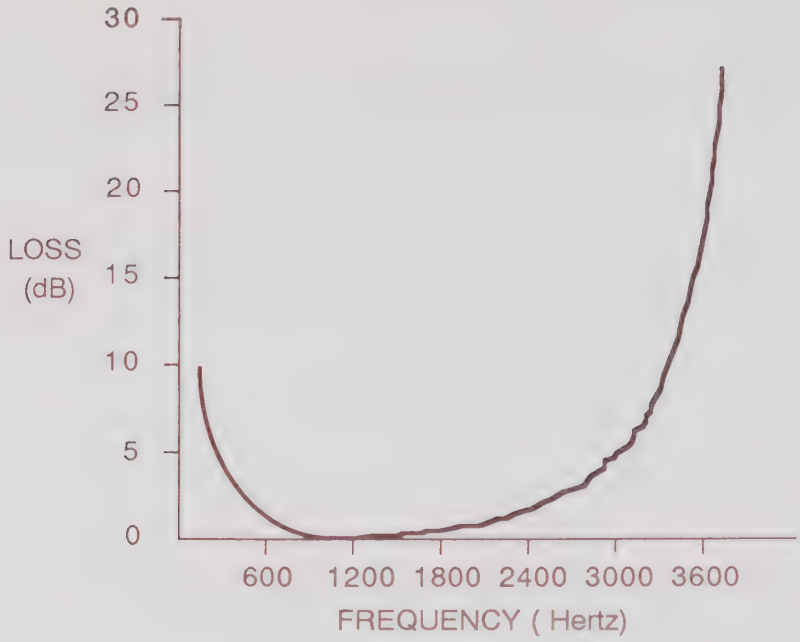
In this section the various impairments and their sources are discussed.

6-4.2.1 LOSS AND ATTENUATION DISTORTION

Loss is the measure of attenuation between two points. The effect of loss is to lower signal level and thereby decrease the signal to noise ratio. This makes the data signal more susceptible to errors. Loss is measured by sending a tone at a known level from one end of the circuit and measuring the received level at the far end. The difference between the level sent and the level received is the loss. Loss is usually measured at 1004 Hz with transmitted levels between 0 dBm and -16 dBm depending upon the point at which the tone is injected into the circuit.

Different frequencies will experience different attenuation. Since this loss will not be uniform across a band of frequencies, a form of amplitude distortion can be introduced. Amplitude distortion is defined as the loss at any frequency relative to the loss measured at 1004 Hz.

Loss and attenuation distortion are calculated as positive numbers in the telephone companies, while gain is a negative number. This is opposite to engineering practice but has endured over the years. For example, if the loss at 804 Hz is 4 dB more than the loss at 1004 Hz, then the channel has an attenuation distortion of +4 dB at 804 Hz. A plot of loss in dB versus frequency is shown in Figure 6-1 for a typical voice channel.



ATTENUATION DISTORTION VERSUS FREQUENCY
FIGURE 6-1

C-conditioning involves setting equalization to keep attenuation distortion within tariffed limits.

6-4.2.2 ENVELOPE DELAY DISTORTION

Envelope delay is a measure of the phase linearity versus frequency response of a channel. The propagation time for a signal along a pair of wires varies with frequency. This variation is equal to a relative phase shift. If the shift is non-linear, distortion of the signal results.

Propagation time varies mainly due to the capacitance between wire pairs. This capacitance is increased by bridge taps. Other sources of phase distortion are switching microwave paths to alternate paths, and load coils which also add substantial delay at low frequencies.

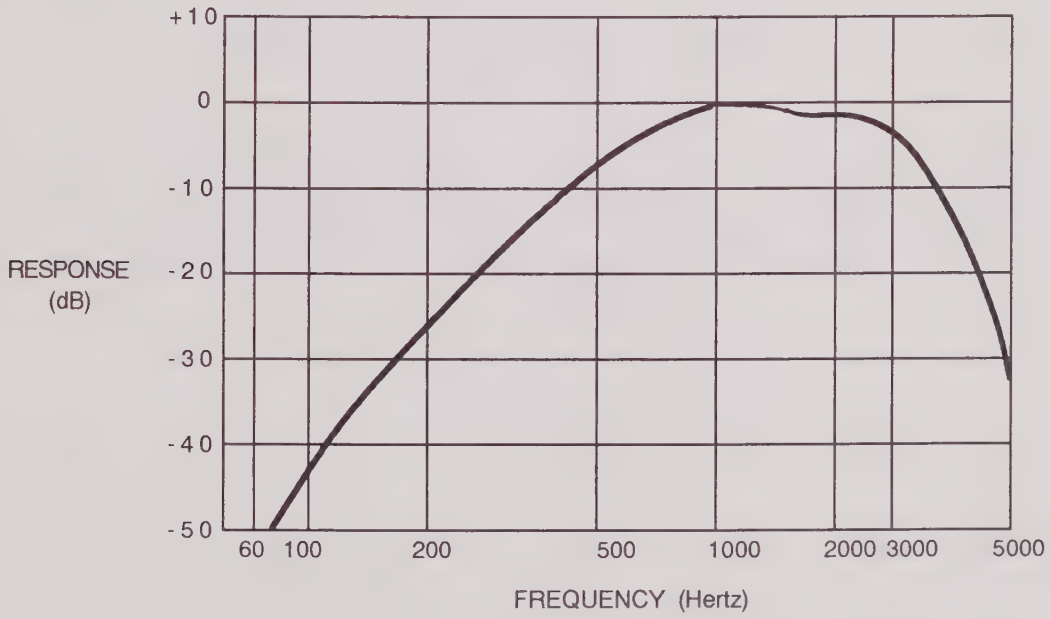
The effect of relative envelope delay is to cause data bits to smear out in time and overlap each other (intersymbol interference). At data speeds above 2400 bps delay distortion inhibits transmission over unconditioned lines because the receiving modem cannot read the smeared bits and errors result. Modems with adaptive equalizers, or equalizers on the lines themselves, smooth delay distortion and permit higher data speeds.

6-4.2.3 NOISE

Noise is always present in communications systems and is a fundamental limit to the information transfer rate over a channel. Noise is often referred to as thermal noise or white noise since it covers the entire frequency spectrum. One source of noise on a channel is the thermal processes in amplifiers, resistances, switches and other active elements. Other sources include radio frequency interference, crosstalk from other channels, and interference from AC power line induction.

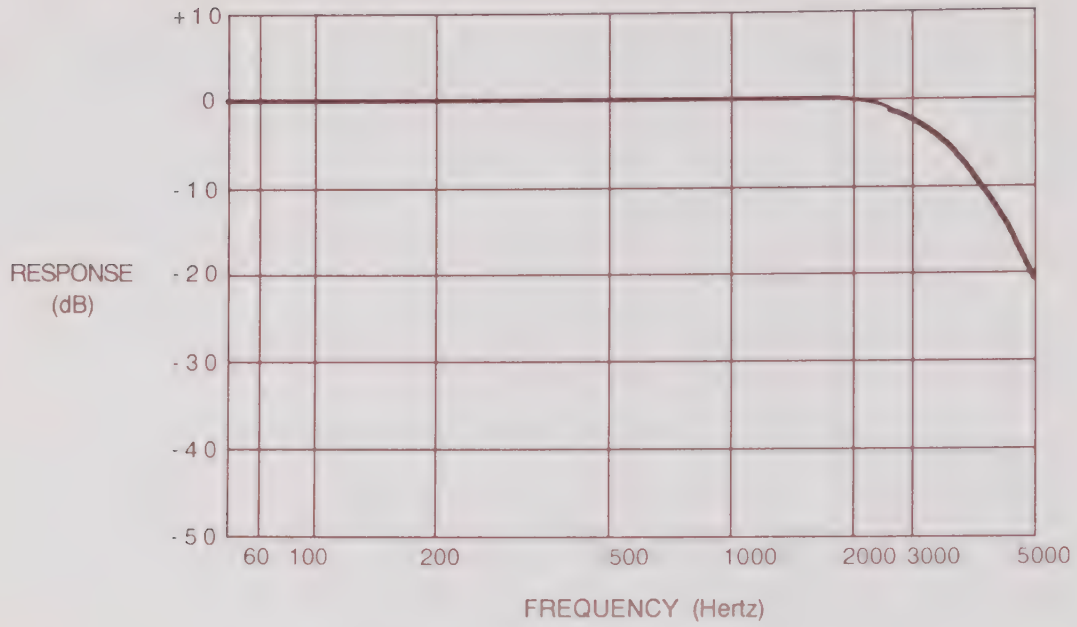
As noise increases, signal to noise ratio decreases and this means a higher probability of error at the receiving modem.

Noise, on telephone circuits, has traditionally been measured using weighting filters which weight the noise reading to correspond to the subjective effect of noise on voice communication. The weighting filters used in North America for 4 KHz voice channels are the C-Message and 3 KHz Flat weighted filters.



C-MESSAGE FILTER CHARACTERISTIC
FIGURE 6-2

This filter is used to measure noise which affects mainly voice communications and is not particularly relevant to data transmission.

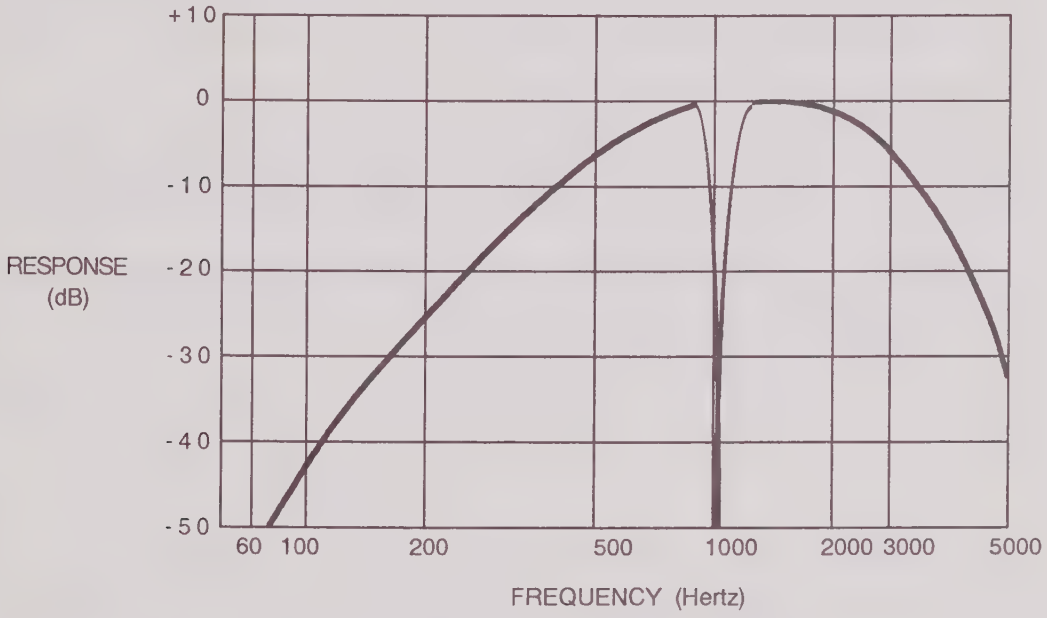


3 KHz FLAT FILTER CHARACTERISTIC
FIGURE 6-3

This filter more nearly approximates the response of modems. Compared to the C-Message filter, it allows the low frequency noise contribution to be measured. By switching between C-Message and 3 KHz Flat filters, various sources of noise may be identified by their characteristic frequency bands.

NOISE WITH TONE

Some elements of the telephone network such as compandors and quantizers are only active when a signal is present. Their noise contribution cannot be measured unless a tone is sent to activate them. A 1010 Hz test tone is usually sent and a notch filter in the test set removes the tone prior to noise measurement. The noise filter in this case consists of a C-Message filter with a superimposed notch filter and is often referred to as a C-Notch filter.



C-NOTCH FILTER CHARACTERISTIC
FIGURE 6-4

SIGNAL TO NOISE

Signal to noise ratio can be computed by comparing the signal level of the received tone with the C-Notch noise measurement. In reality, this is a S+N/N ratio, but if the signal is at least 10 dB higher than the noise, the noise component in the numerator becomes negligible. Signal to noise is a quick estimate of channel quality and is directly proportional to error performance. The higher the signal to noise ratio the higher the probability that the transmission will not have errors.

6-4.2.4 NON-LINEAR DISTORTION

Non-Linear distortion is the production of frequencies at the output which were not present in the original input signal. One form of non-linear distortion produces frequencies at the output which are integer multiples of the original input frequencies. This is Harmonic Distortion. Another form of non-linear distortion produces frequencies which are the sum and difference products of the input frequencies and their harmonics. This is referred to as Intermodulation Distortion.

That is, if there are two frequencies, f_1 and f_2, then their potential products are:

$$f_1+f_2 \ , \ f_2-f_1 \ , \ 2f_1+f_2 \ , \ 2f_1-f_2 \ , \ 2f_2+f_1 \ , \text{ and } 2f_2-f_1$$

Non-Linear distortion is caused by non-linear devices such as amplifiers, modulators, demodulators, compandors and other active elements including switches. The principal cause of non-linear distortion in PCM systems is the quantizing process. This process uses a logarithmic compression law to provide more steps per volt for small speech signals than for large samples. This maintains a substantially constant signal to quantizing distortion ratio over a wide dynamic range. However, the process is inherently non-linear and so produces non-linear distortion.

6-4.2.5 PHASE JITTER

Phase jitter is an undesirable dithering of the phase which appears as phase or frequency modulation. Although unimportant to voice transmission, phase jitter is particularly significant to data. Especially to data modems using phase modulation techniques. Phase jitter causes variations in the zero crossings of pulses and this results in pulses moving into other pulses time slots.

Phase jitter is measured by sending a test tone of 1004 Hz at data level over the line under test. At the receive end a phase locked loop establishes a phase reference and jitter is measured relative to this reference.

The frequency of the phase jitter characterizes its source. Phase jitter caused by ringing current in adjacent channels is at 20 Hz. AC power supply induced currents are a common source of jitter at 60 Hz. Harmonics of these frequencies up to the fifth order can be a source of jitter.

Phase jitter measurements are made over a 4 Hz to 300 Hz range in three bands: 4 Hz to 20 Hz; 20 Hz to 300 Hz; and the entire 4 Hz to 300 Hz band.

Jitter standards for data transmission are no more than 10 ^{o} between 20 Hz and 300 Hz and no more than 15 ^{o} between 4 Hz and 300 Hz.

6-4.2.6 IMPULSE NOISE

Impulse noise is a transient phenomena and is characterized by short duration bursts of noise energy called spikes. These spikes are normally less than 1 millisecond in duration. The effects of an impulse noise spike usually disappear within 4 milliseconds.

Impulse noise is caused by such things as the action of electromechanical switches and relays, installation and maintenance activity, and weather disturbances such as lightning.

On voice channels the impulse spikes are an annoyance but communications are still possible. On data transmissions however, the noise bursts can cause a loss of information bits which causes errors. In slow data rate systems (<300 bps), impulse noise is less of a problem because the receiver can distinguish a data pulse from an impulse burst. As the data rate increases it becomes impossible for the receiver to distinguish between a data pulse and a noise pulse. This results in impulse noise related errors.

6-4.2.7 GAIN HITS

Gain hits are another transient impairment. Gain hits are characterized as sudden increases or decreases in received signal amplitude. They are defined as being less than a 12 dB change in level and lasting for 4 milliseconds or longer. Gain hits may last for hours. Gain hits may look like data pulses to modems which use amplitude modulation.

Internal telephone company standards call for no more than 8 gain hits of more than 3 dB change from the nominal received signal level in a 15 minute period.

6-4.2.8 DROPOUTS

Dropouts are a more severe form of gain hits. Dropouts are defined as a decrease in received signal level greater than 12 dB and lasting longer than 4 milliseconds. Dropouts interrupt the signal flow and data is lost. Furthermore, when the signal returns, the modems must re-synchronize or re-equalize and more data is lost.

Dropouts occur less frequently than gain hits but their effect is much more severe. Consequently, dropouts have the tightest standards of no more than 1 dropout in 30 minutes.

6-4.2.9 PHASE HITS

A phase hit is defined as a sudden change in the phase or frequency of the received signal which lasts longer than 4 milliseconds. Since most modern modems employ phase shift or frequency shift key modulation techniques, phase hits look like data and cause errors.

Phase hits can occur when switching between carrier supplies in FDM systems or during protection switching from one microwave path to another with different propagation times. These changes may cause all data to be in error until the out of phase condition is cleared.

Internal telephone company standards for phase hits on data circuits are no more than 8 phase hits during a 15 minute period of 20 ^{o} or more.

6-5 IMPAIRMENT MEASUREMENTS

The various transmission impairments and their effects on data have been described in the previous sections. In this section, their measurement using the 930A is described..

REMINDER:

Prior to any testing, the 930A must be set up for the trunk type and supervision being tested. It will do no good to test loss on a Loop Start trunk with the 930A in SF or PCM or something other than Loop Start.

6-5.1 LOSS MEASUREMENT

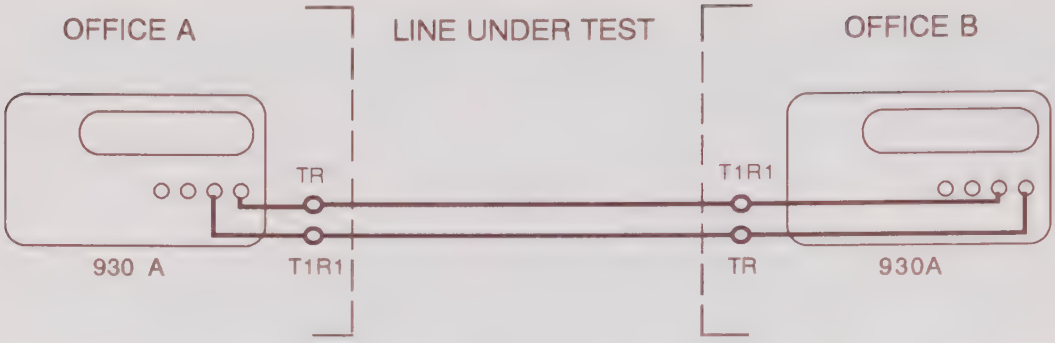
Loss, or 1000 Hz loss as it is called, is an end-to-end measurement meaning that one test set sends the 1000 Hz tone from one end and another test set receives the tone at the other end and measures the difference in level.

In practice, the tone used to measure loss is not 1000 Hz but 1004 Hz. The 4 Hz offset is required to prevent disruption of T-carrier channels since 1000 Hz is a direct sub-multiple of the 8 KHz PCM sampling rate. The circuit must be properly terminated in a non-reactive resistance equal to the characteristic impedance of the trunk under test. Common impedances are:

900 ohms on 2 Wire Metallic trunks
600 ohms on 4 Wire Metallic trunks
100 ohms on T-carrier trunks

1200 ohm points occur on loaded pairs and are not generally accessible. Wideband analog circuits carrying 56 Kbps data are usually 135 ohm lines. The 930A however, does not test wideband analog data on the metallic side.

A typical test set up is diagrammed below:



For 2 Wire measurements only, the Tip/Ring connection is used. For 4 Wire measurements the Tip1/Ring1, as well as the Tip/Ring, connection is used. The above test set-up works for Loop Start, Ground Start, Reverse Battery and SF supervision trunks.

The use of the 930A's E&M leads and Signal Battery/Signal Ground (SB/SG) leads is only required on E&M trunks. These leads would be connected to the appropriate jacks in the telephone company office. End users do not have E&M type trunks which are only used between Telephone company central offices.

To send a 1004 Hz tone at data level (-13 dBm0) from Office A toward Office B, set the 930A in Office A as follows:

1. Press the front panel Trunk Type Function key. Choose the correct supervision type; set for 2 wire or 4 wire operation at the correct impedance as appropriate; select BATTERY (in Loop and Ground Start) or SEND-M (in E&M trunks) and then select TERM to terminate the circuit. The softkeys under the display control all of the set-ups. Refer to Section 3-6 for details.

2. Press the Send Tone Function key and then press Softkey 4 to turn OFF the tone if it is not already off. Press Softkey 1 and the flashing cursor will appear over whatever frequency was previously entered. Press 1, 0, 0, and 4 on the numeric keypad and then press the ENT (Enter) key. Press Softkey 3 and the flashing cursor appears over the level previously entered. Press 1 and 3 on the numeric keypad and then

press the ENT (Enter) key. A level of -13 dBm will be entered. If the transmission level point is not 0 dB, but +7 dB for example, then the level sent should be -6 dBm to achieve a -13 dBm0 referenced level. Likewise, at a -16 dB TLP, the level sent should be -29 dBm to yield a -13 dBm0 referenced level. The user must know what transmission level point is at the test access location.

3. Finally, place the front panel Hook Switch in the OFF HOOK position and press Softkey 4 to turn ON the tone. Refer to Section 3-9 as required.

At Office B, set up the receiving 930A as follows:

1. Press the Trunk Type function key. Choose the appropriate supervision type and set for 2 Wire or 4 Wire operation at the correct impedance. Select CONTACT (in Loop or Ground Start) or SEND-E (in E&M trunks) and then select TERM to terminate the circuit in the correct impedance. The softkeys under the display control all set-ups. Refer to Section 3-6.

2. Press the MEASURE TONE function key and the 930A will measure the received level and frequency. The difference between the transmitted level and the received level is the loss.

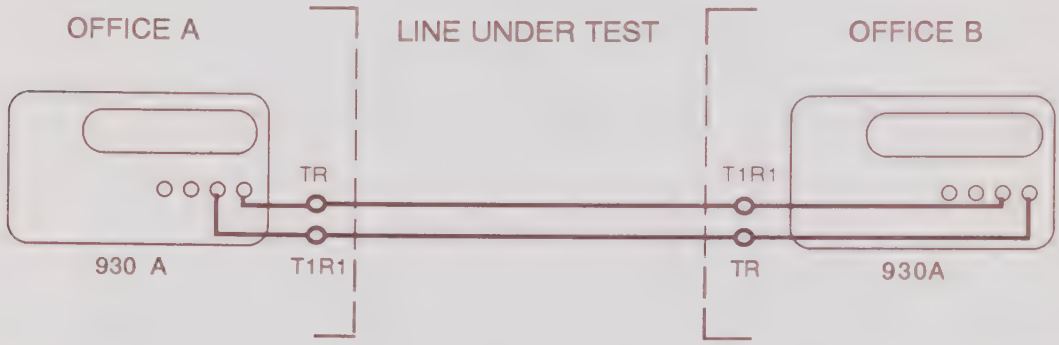
6-5.2 THREE-TONE OR GAIN/SLOPE TONE MEASUREMENT

The so-called three-tone or Gain/Slope measurement, while not a tariffed measurement, is a quick means of spotting potential distortion problems without doing an entire attenuation distortion sweep.

Three tones (404 Hz, 1004 Hz and 2804 Hz) are used to provide an indication of the slope of the attenuation curve for the channel under test from low to high frequency. Since the 1004 Hz tone is usually the reference the other tones are compared to the reading at 1004 Hz. It would be expected that the loss at 404 Hz would be slightly higher than the loss at 1004 Hz and that the loss at 2804 Hz would be much greater. A quick examination of Figure 6-1 will show why this is so.

The Gain/Slope test is made by applying the three tones in sequence at -16 dBm0 at the distant end and measuring the received tone level at the near end of the circuit under test.

Typically, the 1004 Hz tone is sent first because the others are referenced to it. The 404 Hz and 2804 Hz tones are then sent and the difference in received tone level at 404 Hz or 2804 Hz and 1004 Hz is the gain slope. The same test set-up used for the 1000 Hz loss measurement can be used for gain/slope.



For 2 Wire measurements only, the Tip/Ring connection is used. For 4 Wire measurements the Tip1/Ring1, as well as the Tip/Ring, connection is used. The above test set-up works for Loop Start, Ground Start, Reverse Battery and SF supervision trunks.

The use of the 930A's E&M leads and Signal Battery/Signal Ground (SB/SG) leads is only required on E&M trunks. These leads would be connected to the appropriate jacks in the telephone company office. End users do not have E&M type trunks which are only used between Telephone company central offices.

To send the 1004 Hz tone at data level from Office A toward Office B, set the 930A in Office A as follows:

1. Press the front panel Trunk Type Function key. Choose the correct supervision type; set for 2 wire or 4 wire operation at the correct impedance as appropriate; select BATTERY (in Loop and Ground Start) or SEND-M (in E&M trunks) and then select TERM to terminate the circuit. The softkeys under the display control all of the set-ups. Refer to Section 3-6 for details.

2. Press the Send Tone Function key and then press Softkey 4 to turn OFF the tone if it is not already off. Press Softkey 1 and the flashing cursor will appear over whatever frequency was previously entered. Press 1, 0, 0, and 4 on the numeric keypad and then press the ENT (Enter) key. Press Softkey 3 and the flashing cursor appears over the level previously entered. Press 1 and 6 on the numeric keypad and then press the ENT (Enter) key. A level of -16 dBm will be entered. If the transmission level point is not 0 dB, but +7 dB for example, then the level sent should be -9 dBm to achieve a -16 dBm0 referenced level. Likewise, at a -16 dB TLP, the level sent should be -32 dBm to yield a -16 dBm0 referenced level. The user must know what transmission level point is at the test access location.

3. Finally, place the front panel Hook Switch in the OFF HOOK position and press Softkey 4 to turn ON the tone. Refer to Section 3-9 as required.

At Office B, set up the receiving 930A as follows:

1. Press the Trunk Type function key. Choose the appropriate supervision type and set for 2 Wire or 4 Wire operation at the correct impedance. Select CONTACT (in Loop or Ground Start) or SEND-E (in E&M trunks) and then select TERM to terminate the circuit in the correct impedance. The softkeys under the display control all set-ups. Refer to Section 3-6.

2. Press the MEASURE TONE function key and the 930A will measure the received level and frequency.

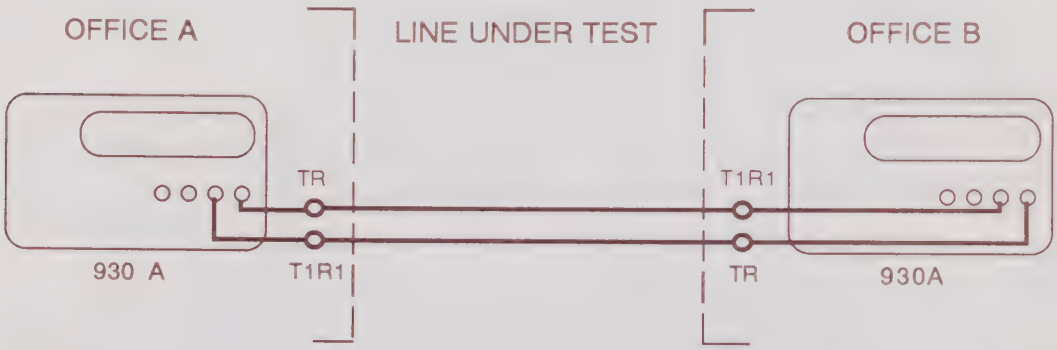
3. Use the received 1004 Hz tone level as a reference by pressing Softkey 2 to change from dBm to the set 0 dB reference. When the 930A reads 0 dB have the sending 930A transmit the 404 and 2804 Hz tones sequentially. The set-up is exactly the same as it was for 1004 Hz except for the frequencies. The receiving 930A will then read the difference in dB directly without any calculations.

6-5.3 ATTENUATION DISTORTION MEASUREMENT

Attenuation Distortion is also a referenced measurement. That is, the loss at frequencies other than 1004 Hz is compared to the loss at 1004 Hz and the difference is the attenuation distortion. In this respect, attenuation distortion is similar to Gain/Slope except that there are now more tones to measure.

Attenuation distortion can be measured using the same test set-up as that used for the Loss measurement in the previous section. In this case though, it is useful to employ the frequency sweep function of the 930A instead of the SEND TONE function. The frequency sweep function, standard on all 930A's, is located in menu option 10 under the OPTION MENU function key.

To use the frequency sweep for attenuation distortion measurement, use the same test set-up used for loss measurement and follow the step by step procedure outlined below.



At Office A:

1. Repeat the 1004 Hz Loss measurement performed in the previous section. Send 1004 Hz at -16 dBm0 from Office A.

2. Press the Option Menu function key on the 930A and then press 1 and 0 and then the ENT (Enter) key to get directly into Menu Option 10: FREQUENCY SWEEP.

3. Set up the frequency sweep (if sweep has been set previously and no changes are needed, proceed to step 4.) by pressing Softkey 2 labeled SET-UP. In

this case Softkey 1 controls the upper and lower bounds of the frequency sweep; Softkey 2 controls the step size (usually 100 Hz); Softkey 3 controls the sweep time (usually 2 to 3 seconds per tone) and the level (usually 16 dB below the TLP); and Softkey 4 exits back to the main menu for testing. Refer back to Section 3-12.4 for details and pictorials on setting up the sweep.

4. To initiate testing from the main sweep menu, press Softkey 3 labeled "SWEEP" and then choose either continuous or single sweep. After the appropriate softkey has been pressed the 930A will sweep between the bounds selected.

At Office B:

1. Place the 930A in the MEASURE TONE function as it was for the Loss measurement. Have the 930A at Office A send the 1004 Hz, -16 dBm0 tone.

2. After the 1004 Hz tone has been received, press Softkey 2 until the display reads "0 dB". The 930A should have been reading in dBm so that a single press of Softkey 2 will set the 0 dB reference. Once the 0 dB reference has been set all of the path aberrations have been zeroed out as well.

At Office A, initiate the frequency sweep over the range desired as described above.

At Office B the 930A will read the difference between the loss at the frequencies being sent and the 0 dB reference level set at 1004 Hz.

It is handy to have a printer connected to the 930A to record the received levels during the sweep.

IMPORTANT NOTE

The 930A measures loss as a negative (-) number. This is opposite to Telephone Company practice but is consistent with engineering practice. To compare readings it is only necessary to change the sign from - to + when checking Telephone Company results.

6-5.4 RETURN LOSS MEASUREMENT

The problem of echo is caused by impedance mismatch and poorly equalized or compensated lines at the interface between the 2 wire subscriber loop and the 4 wire toll network.

A return loss of 30 dB or more is considered very good while 20 dB or less is probably going to result in less than satisfactory transmission.

To measure return loss with the 930A, press the RETURN LOSS function key. Then press Softkey 1 to select either Echo Return Loss, Singing Return Loss-High, Singing Return Loss-Low, or Sinewave Return Loss. The 930A is also capable of either measuring the Trans-Hybrid Loss (THL) or allowing the user to enter the THL value if it is known. This compensation factor, when entered or measured, is automatically subtracted from the return loss measurement.

Press Softkey 2 to send the momentary Echo Suppressor/Canceller disable tone prior to recording any measurements. This ensures that the line under test is clear of these devices before testing. The disable tone is usually between 2000 and 2250 Hz. The 930A uses 2125 Hz as it's default value.

Refer to Section 3-8 for details and pictorials regarding the set-up of the Return Loss function.

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6-5.5 NOISE MEASUREMENT

Noise was discussed in Section 6-4.2.3. The measurement of noise power using the 930A is described in this section.

After selecting the correct trunk type and supervision, press the MEASURE NOISE function key and perform the following steps:

1. Press Softkey 2 to select C-MESSAGE, C-NOTCH or 3 KHz FLAT weighted filter depending upon the type of test being performed. Select S/N if a Signal to Noise ratio test is to be performed.

2. Press Softkey 4 to select Balanced or Noise to Ground measurement. Balanced noise measurements are normally performed on subscriber circuits. Noise to Ground measurement provides a measure of the longitudinal noise present on a voice channel with reference to ground.

3. The distant end of the circuit should be in a "Quiet Termination" mode. If another 930A is connected at that end, then quiet termination is achieved by placing that unit in SEND TONE and pressing Softkey 4 to turn the Send Tone function "OFF".

Noise to Ground measurements are usually made for troubleshooting purposes and to measure the magnitude of longitudinal signals. This indicates the susceptibility of a cable pair to electrical coupling from external sources such as induced AC power (60 Hz) or Ringing (20 Hz).

To calculate the relative line balance perform the following steps:

1. With the 930A in MEASURE NOISE, press Softkey 2 to select the 3 KHz FLAT weighted filter.

2. Press Softkey 4 to select the balanced measurement mode.

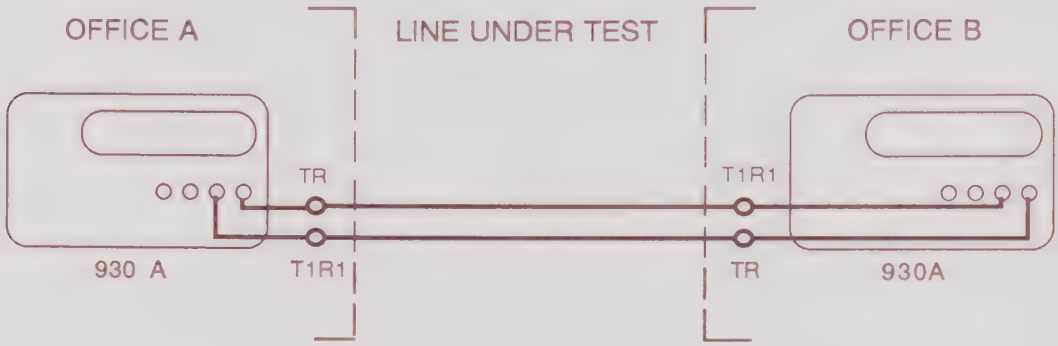
3. Record the reading of message circuit noise in dBrn.

4. Press Softkey 4 to select the Noise to Ground mode.

5. Subtract the Noise to Ground measurement value from the Balanced reading to compute the relative line balance. A smaller reading (closer to 0) indicates a better balance.

Signal to Noise measurements are performed with a holding tone and are end to end measurements. The holding tone can be anything from 995 Hz to 1025 Hz but 1004 Hz and 1010 Hz are the most common tones used and are sent at data level (usually -13 dBm0).

To set up the 930A for Signal to Noise measurements perform the following steps:



1. Set the 930A in Office B to the SEND TONE function and select 1010 Hz at a -13 dBm0 level.

2. Set the 930A in Office A to MEASURE NOISE. Press Softkey 2 to select S/N and record the reading.

Signal to Noise ratio provides a measure of the separation between the desired signal and the background noise. If the separation gets too small, the receiver may be unable to distinguish the signal from the noise. Unconditioned and C-Conditioned lines have a minimum S/N of 24 dB while D-Conditioning specifies a 28 dB minimum S/N. The higher the S/N ratio is, the less susceptible a modem will be to impairments.

Noise with Tone or Notched Noise is noise measured with a holding tone present to turn on all the tone activated components in the transmission path. This provides a more accurate measure of the noise while a data signal is present. It includes the noise contributions from active elements such as compandors that are only active when a signal is present.

To measure noise with tone using the 930A, the test can be set up as an end to end measurement or a single 930A can be used if the distant end is looped back (4 wire circuits only).

For an end to end measurement of notched noise, perform the following steps:

1. Set the far end 930A to SEND TONE and select 1010 Hz at -13 dBm0.

2. At the near end 930A, press the MEASURE NOISE function key and then press Softkey 2 to select the C-NOTCH weighted filter.

The value of the noise with tone is given in dBrnC. The C-NOTCH filter is a C-MESSAGE filter with a notch centered at 1010 Hz. The 930A has a notch filter with a notch depth in excess of 65 dB and very steep skirts to ensure that the holding tone is removed without causing a serious discrepancy in the noise measurement.

6-5.6 IMPULSE NOISE MEASUREMENT

Impulse noise is measured by counting the number of times the noise spikes exceed preset threshold levels. The preferred measurement technique employs three threshold levels. This is the method used by the 930A.

To measure Impulse Noise with the 930A it is first necessary to select the correct trunk type as this is the start of all test procedures for the 930A.

After setting up the correct trunk type and supervision, connecting the test cords to the appropriate jacks and ensuring that Impulse Noise is audible on the 930A speaker, perform the following steps:

1. Press the Option Menu function key and then press 1, 1 and ENT (Enter) key to go to Menu Option 11: 3-LEVEL IMPULSE NOISE.

2. Press Softkey 2 labeled SET-UP if it is necessary to change previously entered parameters. If no change is desired go straight to MEASURE. Pressing the SET-UP Softkey will lead to a choice between the DEFAULT parameters or the MANUAL mode which allows the user to change any or all of the parameters.

3. To measure Impulse Noise on metallic trunks use the DEFAULT test set-up parameters which are:

   54 dBrnC Low Threshold
   4 dB steps between thresholds
   15 Minute test duration
   7 measurements per second

4. To measure Impulse Noise on T-Carrier trunks it is necessary to use the MANUAL mode to set up the test. After pressing the Softkey labeled "MANUAL", press the Softkey labeled "C-NOTCH" to measure Impulse Noise with holding tone present or C-MESSAGE if it is required to measure without the holding tone.

5. Press the Softkey labeled THRESHold. Enter 6, 7 and press the ENT (Enter) key to change the Low threshold to 67 dBrnC which is the T-Carrier low threshold setting. Metallic trunks have a 54 dBrnC low threshold which is the 930A's default value.

All of the other parameters would stay the same to perform a standard measurement but the user could also change step size, measurement duration or measurements per second.

6. After setting up the test parameters, press the Option Menu function key once to return to the Impulse Noise display. Press Softkey 3 labeled "MEASURE" and then press Softkey 4 labeled "START" to begin testing.

7. To stop the test at any time, press Softkey 4, now labeled "STOP?".

8. Press the Option Menu function key to exit from the Impulse Noise menu.

Impulse Noise is not a tariffed parameter and so the telephone company internal standards are the controlling documents. Impulse noise is normally allowed no more than 15 counts above the low threshold during a 15 minute period. Also, no more than 9 counts above the low threshold + 4 dB (Mid Threshold) and no more than 5 counts above the low threshold + 8 dB (High Threshold) are allowable during the same 15 minute period. The number of measurements per second is normally 7. Refer to Section 4-5 for details and pictorials of the Impulse Noise option.

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6-5.7 PEAK TO AVERAGE RATIO (P/AR) MEASUREMENT

The P/AR measurement option provides a figure of merit for a channel. P/AR measures the overall spreading and smearing in time of a data-like signal traversing the channel. Smearing of a data signal is the result of several impairments and causes intersymbol interference.

The P/AR transmission is a complex waveform composed of sixteen non-harmonically related tones with a known envelope shape.

At the receiver, the peak to average ratio is calculated and compared to the known P/AR envelope. Ideally, such a comparison would yield a P/AR value of 100 indicating no degradation. In the real world, however, there are impairments. P/AR is most sensitive to envelope delay, attenuation distortion and noise.

Unfortunately, P/AR readings cannot pinpoint the impairment responsible for the degradation but they do provide a quick indication of possible problems. In fact, envelope delay distortion measurements are not performed for troubleshooting in the telephone companies unless the P/AR measurement has failed to meet guidelines.

Since P/AR is basically a figure of merit, it is usually compared to previous readings to determine changes in transmission quality. A deviation of more than +/- 4 P/AR units from previous readings indicates a significant change in some transmission parameter. P/AR is not a tariffed measurement and so telephone company standards are used to establish the objectives.

A minimum P/AR reading of 50 is required on end to end connections. An individual link, either an end link or mid link connection must have a minimum P/AR reading of 80.

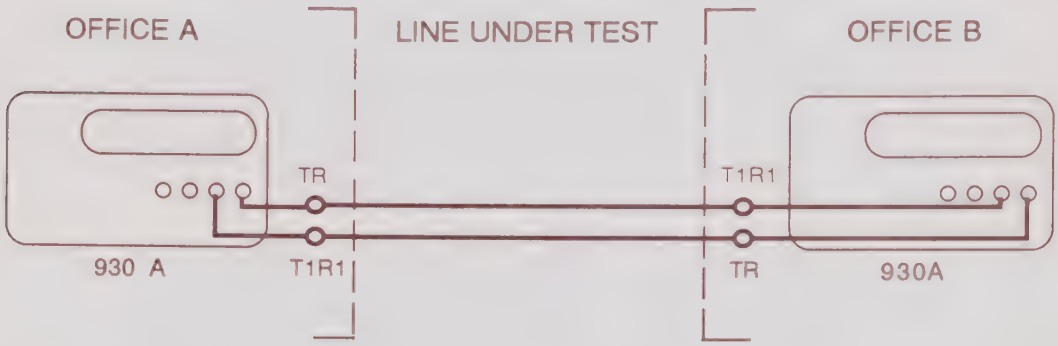
On T1 carrier trunks, a P/AR reading of as much as 102 P/AR units is allowable while the maintenance limit is a minimum of 93 P/AR units. A typical P/AR measurement on a T1 trunk should be about 97 P/AR units.

Minimum P/AR values for non-repeatered cable less than 18,000 feet long are 97 for non-loaded and 94 for loaded cable.

Minimum P/AR values for repeatered cable are: 90 P/AR units for non-loaded cable less than 18,000 feet long, 90 P/AR units for loaded cable

less than 36,000 feet long, and 80 P/AR units for loaded cable more than 36,000 feet long.

To measure P/AR using the 930A requires one unit to send and one to receive since P/AR is an end-to-end measurement. P/AR is not performed on a loopback basis due to the possibility of cancelling certain impairments. The same test set-up used for loss measurement can be used for P/AR. A 4-wire circuit is shown below.



At Office A set the near end 930A as follows:

1. Press the Option Menu function key and then enter 1, 8 and press the ENT (Enter) key to go to menu option 18: P/AR.

2. Press Softkey 2 labeled "SEND" and enter the transmit level of the P/AR signal using the numeric keypad. P/AR is usually sent at data level (-13 dBm0). If the TLP is not 0 but -16 dB, for example, then the transmitted level should be -29 dBm to yield a -13 dBm0 level.

3. Press Softkey 3 labeled "MEASURE" to begin sending and measuring the P/AR signal on 4-wire circuits or to receive P/AR on 2-wire lines.

At Office B set the far end 930A as follows:

1. Press the Option Menu key and enter 1, 8 and press the ENT (Enter) key to enter the P/AR menu.

2. Press Softkey 2 labeled "SEND" and set the transmit level of the P/AR signal if necessary in the same manner as before.

3. Press Softkey 4 to exit back to the main P/AR menu and then press Softkey 3 labeled "MEASURE" to begin P/AR measurement.

This procedure makes a P/AR measurement in each direction. The 930A can either send or receive P/AR on 2 wire circuits but naturally it cannot do both simultaneously. When measuring P/AR on a 2-wire circuit, one end must be set the SEND mode while the other end must be set to the MEASURE mode. After a P/AR reading has been obtained from the MEASURE end of the trunk then the two test sets should reverse which one is SEND and which is MEASURE so as to allow a P/AR reading at the other end.

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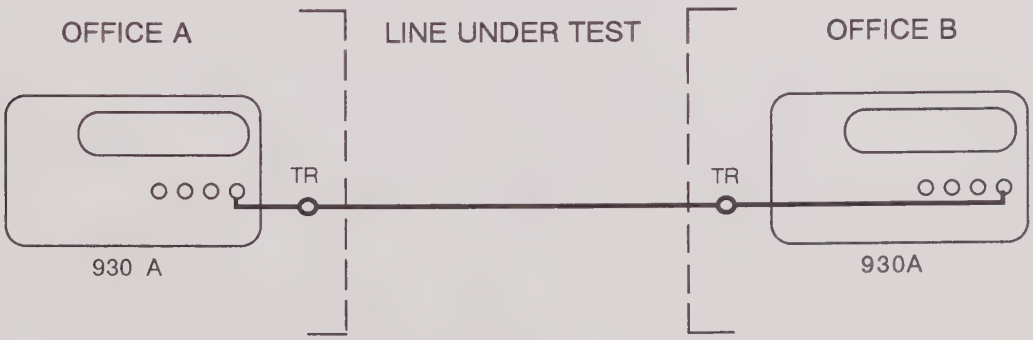
6-5.8 INTERMODULATION DISTORTION MEASUREMENT

Intermodulation Distortion or Non-Linear Distortion was described briefly in Section 6-4.2.4 and in Section 4-10. The purpose of this section is to provide the user with a step by step example procedure for performing an IMD measurement to complement the example in Section 4-10.

Prior to performing the Intermodulation Distortion test by sending and measuring the four test tones, the user must perform the Signal-to-Noise test in order to establish whether the distortion is due to overdriving the trunk under test. Most modern test sets are also able to correct their IMD measurement results for Signal-to-Noise automatically. Therefore, it is necessary for the test set to first perform this test and store the S/N value for use in correcting the IMD results.

The Model 930A, when equipped with Option 930A-20, enables the user to measure the S/N ratio and then make an automatically corrected measurement of Intermodulation Distortion. IMD is an end-to-end test and in this example, a two-wire circuit will be used. It will also be assumed that the circuit is a C1 conditioned line.

As with each measurement using the 930A, the starting point is selecting the correct trunk type and supervision. Next, the test cords must be connected to the appropriate jacks on the 930A front panel and to the circuit. The following diagram shows a two-wire trunk with a 930A connected at each end of the circuit.



Once these steps have been performed at each end of the circuit, the operator is ready to begin testing.

To begin, press the OPTION MENU function key on the 930A in Office A and perform the following steps in order:

1. Use the numeric keypad to enter 19 and then press the ENT (Enter) key.

2. Once inside the menu option, the first screen is the main menu. The display over Softkey 2 should read "SEND". Press Softkey 2 to select the SEND mode.

3. The next step is to adjust the send level to the correct value for the trunk under test. A common value is -16 dBm and this is also the 930A default value. To change the value use the numeric keypad to enter the desired value and then press the ENT (Enter) key to initiate the change.

4. Now send the Signal-to-Noise test tones by pressing Softkey 1 which is beneath the displayed words "SIG/NOISE".

At Office B, press the OPTION MENU function key and perform the following steps:

1. Use the numeric keypad to enter 19 and then press the ENT (Enter) key.

2. Once inside the menu, press Softkey 3 which should be below the word "MEASURE". The 930A display should be reading the S/N ratio and should display the message "S/N TEST".

At Office A, perform the following steps:

1. Press Softkey 2 under the displayed words "4-TONE" to begin sending the 4 IMD test tones.

At Office B the 930A will display the corrected values of the second and third order Intermodulation Distortion products as well as the average received level of the four test tones.

For this example, assume that the readings on the 930A at Office B are:

2nd = 27 dB
3rd = 29 dB

In this case, since a C1 conditioned line was assumed, the reading for signal to 3rd harmonic distortion is 1 dB low. This may or may not be a problem. It certainly indicates a marginal trunk but may not be cause for maintenance unless a customer has complained of transmission errors.

The next step is to reverse the procedures and test the line toward Office A from Office B. In this case, assume that the following readings were obtained from the 930A at Office A:

2nd = 22 dB
3rd = 24 dB

In this case the decision is more clear cut. This trunk would appear to have a problem which is worse in one direction than in the other and clearly fails all the criteria form Office B toward Office A. A one way test on this trunk might not have provided cause for maintenance action but testing both directions clearly points up the need.

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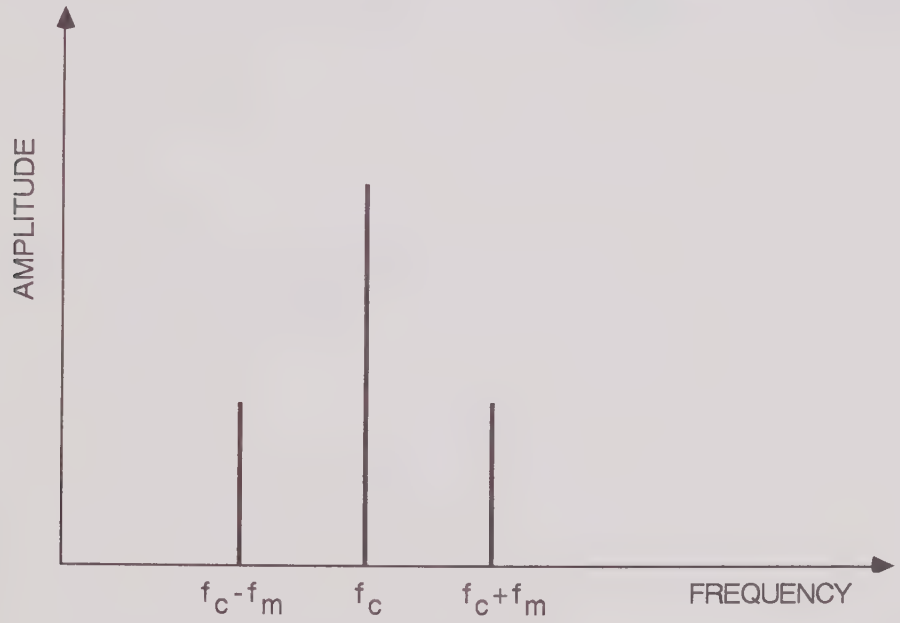
6-5.9 ENVELOPE DELAY DISTORTION MEASUREMENT

Envelope Delay Distortion is a critical parameter on circuits carrying voice-band data traffic. Envelope Delay has no impact on voice traffic but can cause phase distortion which smears data bits and causes them to be unreadable.

Measuring the phase characteristic of a circuit directly is not practical due to the difficulty involved in establishing a phase reference at both ends of the circuit simultaneously. However, there is a way to measure the phase shift between two tones transmitted down the circuit. Examine the spectrum of a pure, undistorted Amplitude Modulated signal as diagrammed below:



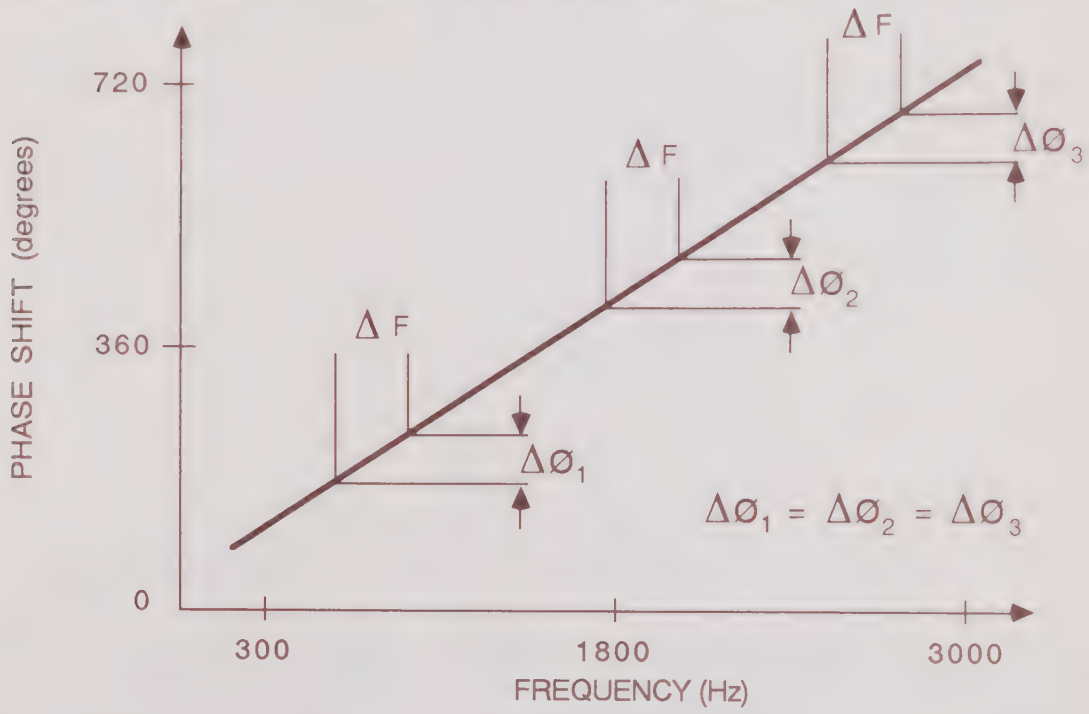
Amplitude Modulation produces a spectrum, such as that shown above, composed of the carrier frequency (f_c) plus an upper and lower sideband (f_c+f_m ,f_c-f_m). The modulation contains the information being transmitted by the AM signal. In this case the information is the phase shift or delay difference between the modulation envelopes of the upper and lower sidebands.

If the modulating frequency f_m is held constant, there should be no frequency difference between the upper and lower sidebands even if the carrier frequency f_c changes. Similarly, if there were no phase distortion,

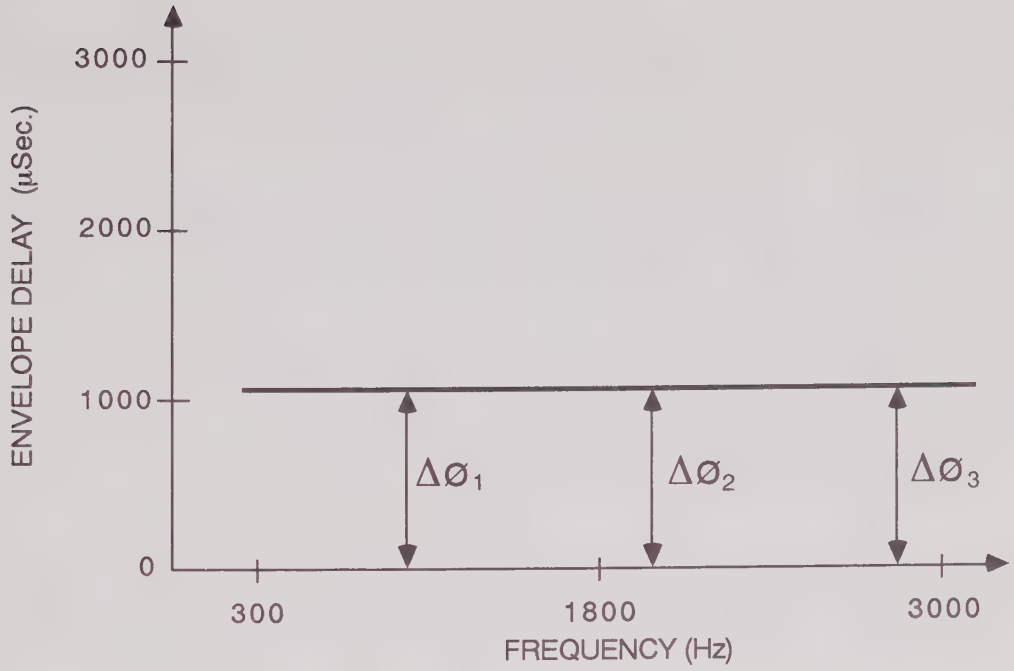
then the delay for a constant f_m would also be constant even for a changing f_c. This fact forms the basis for the envelope delay distortion measurement.

If an AM signal is transmitted over a telephone circuit, the phase shift resulting from this less than perfect transmission medium can be used to determine the delay in the envelope of the modulation and thus the amount of distortion.

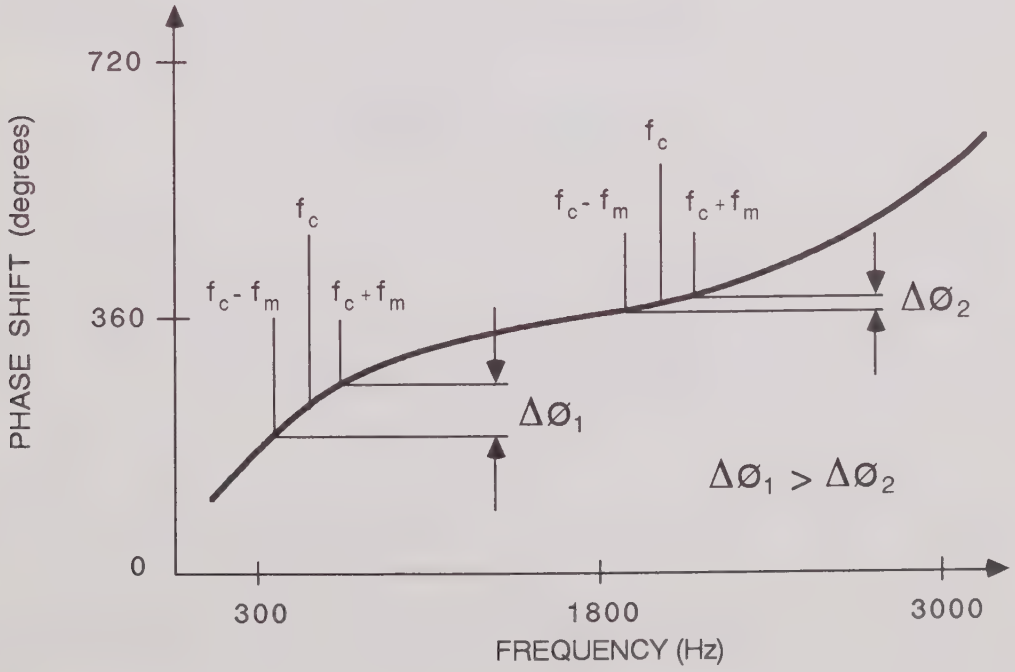
Consider first an ideal or perfect circuit with no non-linearities. In such a circuit the phase characteristic is linear. That is, the phase shift stays constant as frequency changes. A linear phase diagram is shown below.



The phase difference $\Delta\emptyset$ for a constant change in frequency ΔF is the same anywhere along the above characteristic. In such a case, the envelope of the modulation would be delayed by a constant amount over the same frequency range as the carrier frequency was changed. The ΔF in the above diagram represents the bandwidth of the AM spectrum or $2f_m$. A diagram of envelope delay for a linear phase characteristic circuit is presented on the following page.

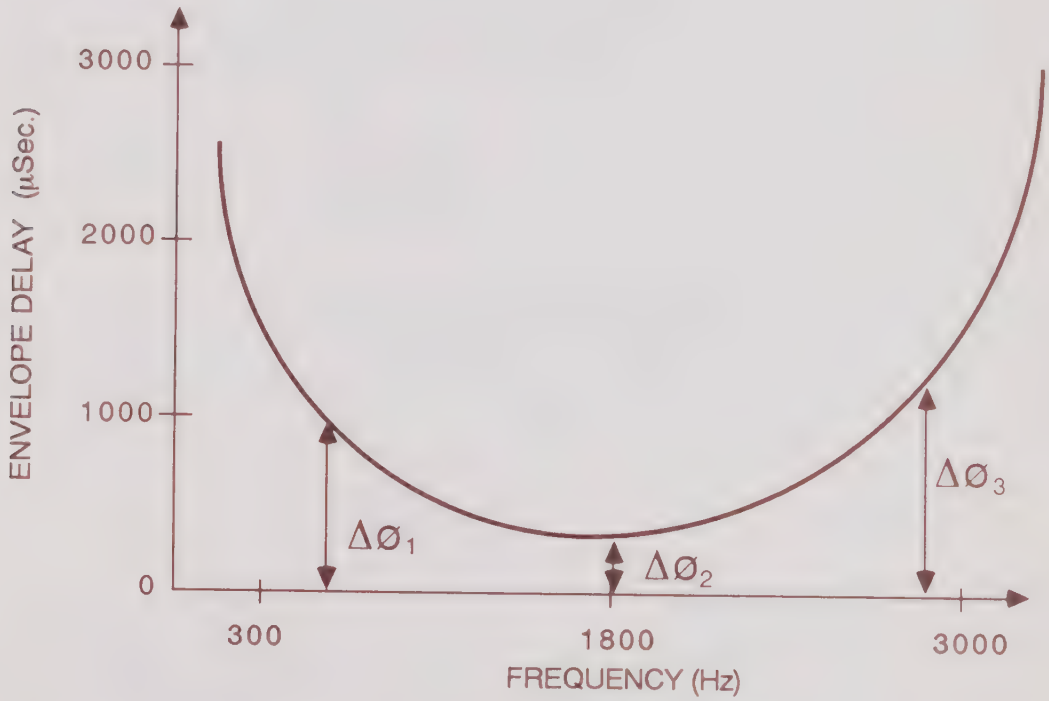


In the real world, the linear phase characteristic is not the case. In fact there are numerous sources of non-linearities on telephone lines. A non-linear phase characteristic, typical of a real world environment is shown below:



From the previous diagram it is apparent that even though the modulating frequency has remained the same, the phase difference has not remained constant as the carrier frequency was changed.

The delay of the modulation envelope will not be constant in this case since the phase shift is no longer linear. This provides the basis for a measurement technique. Envelope Delay is measured and used to provide an indication of the amount of phase distortion on the circuit. A typical Envelope Delay characteristic with phase distortion present on the circuit is shown below:



If the delay of the modulation envelope is measured across the band of frequencies as the carrier frequency is varied over the bandwidth of the circuit, then this provides an indication of the amount of phase distortion on the circuit.

The modulating frequency is usually $83^{1}/_{3}$ Hz and the carrier frequency is varied from 304 Hz to 3504 Hz in 100 Hz steps. Other modulating frequencies such as 25 Hz and $41^{2}/_{3}$ Hz may also be used.

Envelope Delay is measured in microseconds and is referenced to the delay at 1804 Hz.

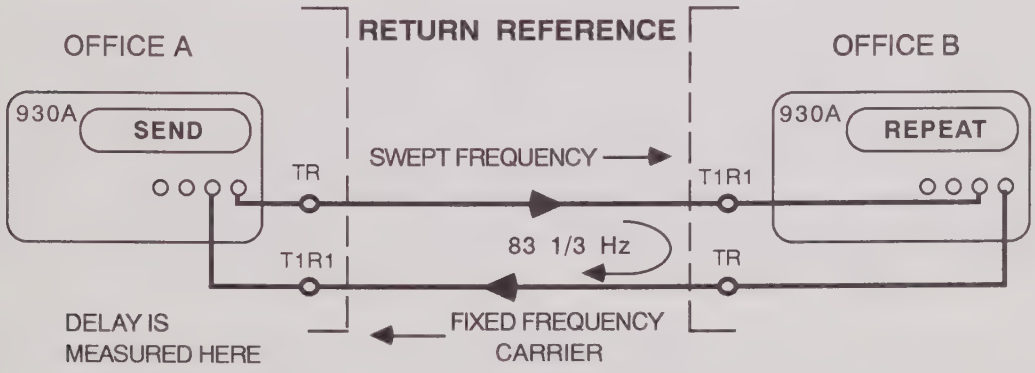
Envelope Delay is an end-to-end measurement and requires a test set at each end of the circuit. One test set transmits the test signal consisting of an Amplitude Modulated waveform. The test set at the far end receives the AM waveform, saves only the modulation envelope, and uses it to modulate a fixed carrier frequency which is then sent back to the transmitting set. The delay introduced on the return path can be zeroed out. The transmitter compares the phase of the original f_m transmitted to that of the f_m which was re-transmitted from the far end and the difference is the envelope delay. Since this measurement is referenced to the delay at 1804 Hz, the delay at 1804 Hz is always set to 0. All readings at other frequencies are then relative to the 1804 Hz reference. If, for example, the envelope delay reading at 1004 Hz was 350 microseconds, this would mean that the delay at 1004 Hz was 350 microseconds more than the delay at 1804 Hz.

Refer to Table 6-1 for the tariffed limits of Envelope Delay Distortion for C-Conditioned lines. Envelope Delay Distortion is a required measurement when turning up C-Conditioned lines as well as during maintenance testing.

The following example describes step-by-step procedures for performing an Envelope Delay Distortion measurement using the 930A.

6-5.9.1 MEASURING ENVELOPE DELAY DISTORTION

In this example, a Model 930A is connected at each end of the 4-wire trunk under test as shown in the diagram below:



Select the correct trunk type as described in Section 3-6 and connect the 930A as described in Section 3-4.5. Complete this step before proceeding.

Once this has been accomplished, the following steps should be performed in order to make a manual measurement of envelope delay distortion:

For each 930A:

1. Press the OPTION MENU function key.
2. Use the numeric keypad to enter the number 17.
3. Press the ENT (Enter) key to complete the numeric entry.

At the Far End 930A:

4. Press Softkey 3 to enter the REPEAT mode.

At the Near End 930A:

5. Press Softkey 2 to enter the SEND mode.
6. After the display has settled press Softkey 4 labeled "SETREF" to set the 0 μsec. reference.
7. Press Softkey 4 (now labeled "SWEEP") again to begin a Return Reference measurement.

Since the 930A operates from default set-up values stored in memory, it is not generally necessary to change the parameters of the test. This makes the 930A easy to use on what is usually a very difficult measurement. The 930A default settings are: Sweep from 304 Hz to 3204 Hz in 100 Hz steps (with SF skip) with a time between steps of 3.5 seconds transmitting at a -16 dBm level.

Once the Return Reference sweep has been completed, the near end 930A will stop and send the fixed reference frequency carrier of 1804 Hz at -16 dBm toward the far end. The operator at the far end must now press Softkey 4 labeled "SWEEP" to send the sweep frequencies toward the near end. This is the Forward Reference measurement because the near end is now supplying the reference toward the far end while the delay is being measured on the return path.

Envelope delay is one of those measurements no one likes to make because of the problems in coordinating an end to end measurement with the people at the far end.

Section 4-12 provides an in-depth treatment of the possible settings and options available for the 930A when measuring Envelope Delay.

6-5.10 PHASE/AMPLITUDE JITTER AND HITS MEASUREMENT

This section expands upon the information presented in sections 4-11, 6-4.2.5, 6-4.2.7, 6-4.2.8 and 6-4.2.9. Phase Jitter is a parameter which is important to measure on circuits carrying voiceband data but which has no impact on speech circuits.

Prior to making a measurement of phase jitter, the C-Notch Noise measurement must be made to assure that excessive noise is not the cause of the phase jitter.

The Model 930A can make three types of measurements of phase jitter. These measurements are differentiated by the frequency band over which they are performed. They are: the Standard (20 to 300 Hz), the LF or Low Frequency (4 to 20 Hz) and the STD + LF (4 to 300 Hz). Phase Jitter is measured by sending a 1004 Hz holding tone at -13.0 dBm as a reference and then recovering the tone at the far end using a phase-locked loop. The phase-locked loop error voltages, instead of being used to correct the received signal, are used as an indication of the phase jitter present on the incoming 1004 Hz tone reference.

The 930A also measures Amplitude Jitter over the same frequency ranges as Phase Jitter.

The measurement of Hits or Transients consisting of Phase Hits, Gain Hits and Dropouts is also provided under Option 930A-18 and the results are displayed as a sub-menu of the Impulse Noise measurement.

The set-up of the 930A for the measurement of Phase and Amplitude Jitter is relatively painless and is covered in Section 4-11.1. The interpretation of the results of the measurements and possible sources of problems is also covered there. Section 4-11.2 describes the measurement of Phase Hits, Gain Hits and Dropouts as well as 3-Level Impulse Noise.

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